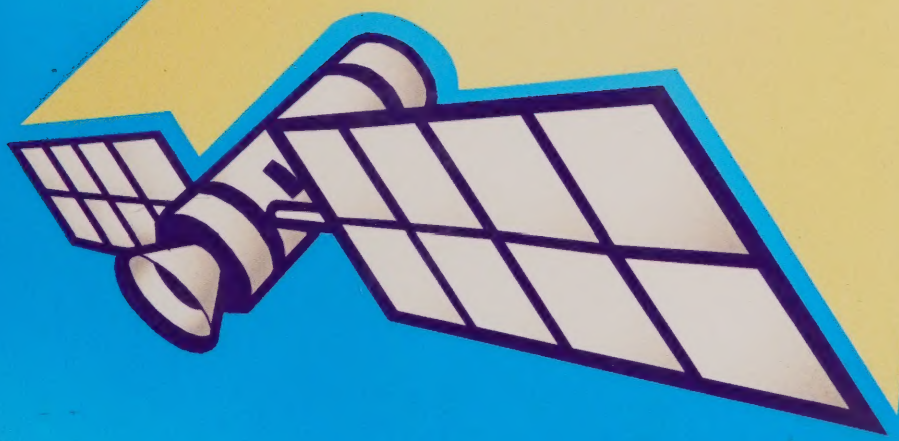
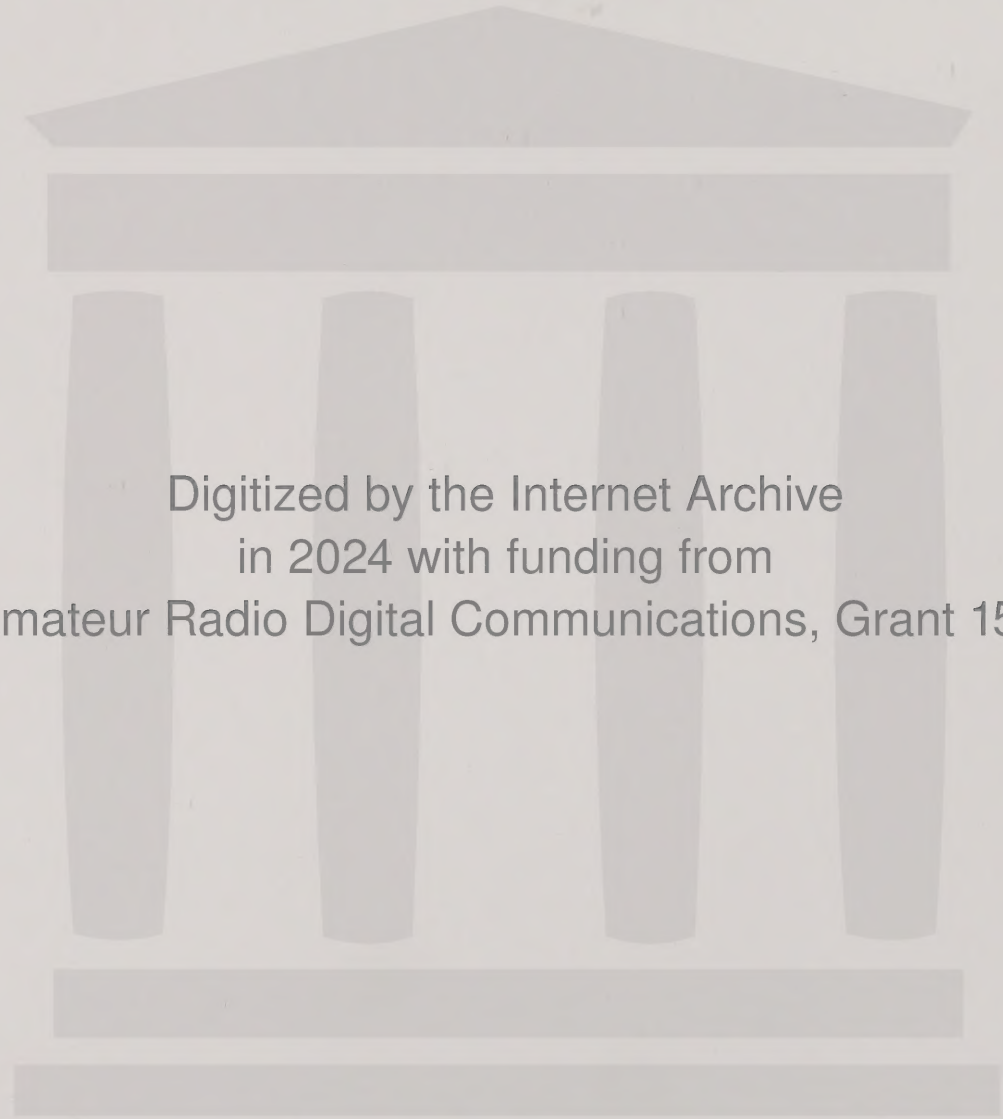
THE PRACTICAL GUIDE TO SATELLITE TV

Fourth Edition



by Garry Cratt



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Preface

Despite the increasing interest in satellite TV and the hundreds of free channels being broadcast around the world, readily available information on the subject continues to be scarce. Like the personal computer in 1980, satellite TV is often thought to be the sole domain of scientists, engineers, and techno "freaks".

Nothing could be further from the truth. Satellite TV reception is perfectly straight forward and can be embraced by anyone interested enough to learn.

This book is the proof. Written by someone with few formal qualifications, every subject covered is the result of hands on experience and the subsequent logical explanation.

Deliberately omitted from this book are complicated mathematical calculations, scientific jargon, cartoons, and the pages of irrelevant information often encountered in other texts. Included are practical answers to all aspects of satellite television reception for our part of the world.

As satellite TV expands, the world shrinks. Perhaps this book will help you to be part of this growing industry.

Acknowledgements

I would particularly like to thank the following, who unwittingly played an important part in making this book possible. Vic Barker, who introduced me to satellite television in its infancy in the late 1970's, Dick Smith, for providing me with the opportunity to research satellite television, Bob Cooper, who influenced me during the 1980's with his outspoken satellite publications and continues to do so today, Fraser Hickox for his constant engineering support, Lindsay Jorgensen who pioneered commercial satellite TV reception in PNG, Anne Ames who, through Orbit International magazine, opened my eyes to the international appeal of satellite TV reception, and the thousands of customers who have provided feedback and support since 1990.

This fourth edition could not have been produced without the patience and support of David Shaw and Robert Anderson, who guided me through the maze of desktop publishing, and Leo Simpson and Ross Tester of Silicon Chip Magazine for many of the photographs used.

Finally to my best friend and partner of 16 years Vicki Harbutt, who has provided constant moral support despite having to endure years of backyard satellite experimentation and subsequent disruption to regular TV viewing....thank you.

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About the author

Garry Cratt trained at AWA Research and Development, prior to an 11 year career at Dick Smith Electronics. He has written numerous articles for electronics magazines over the last 10 years, and is now Technical Director of AV-COMM Pty Ltd.

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Asiasat 4	122E
iPSTAR-1	120E
Palapa C2	113E
Sinosat 1	110E
APR-2	110E
Telkom 1	108E
Cakrawarta	107.7E
Asiasat 3	105.5E
Asiasat 2	100.5E
Gorizont 28	96.5E
NSS-6	95E
Insat 3a	93.5E
Measat 1	91.5E
Measat 3	91.5E
ST-1	88E
Chinastar	87.5E
Intelsat 709	85E
Insat 2E	83E
APR-1	83E
Thaicom 3	78.5E
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Panamsat 4	72E
Panamsat 7	68.5E
Panamsat 10	68.5E
Intelsat 704	66E
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History of Satellite Television

Concept

The history of the development of satellite communications spans a mere 57 years.

The concept of satellites orbiting the earth as spaceborne repeaters was first publicly proposed by Arthur C Clarke, in the October 1945 edition of Wireless World magazine.

In his article "Extra Terrestrial Relays", he envisaged three satellites, orbiting at the same rotational velocity as the earth, acting as giant relay stations far above the earth.

As early as 1929, Austrian engineer Herman Potocnick (he wrote using the name Hermann Noordung) had envisioned that an object placed over the equator at an altitude of 37,500km and an orbital speed of around 11,000km per hour would be synchronized with the rotational speed of the earth.

Evolution

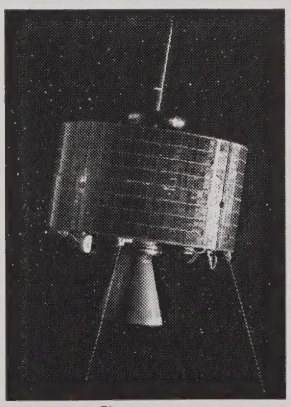
In 1950, prior to the development of communications satellites and modern orbital theory, the US Navy used the moon as a passive reflector for low data rate communications between Hawaii and Washington.

In October 1957 the first man made satellite launched into orbit was the Russian "Sputnik 1". It circled the earth for 21 days in a low polar orbit that required constant tracking adjustments to receive the Morse Code signal it transmitted.

In January 1958 the USA launched "Explorer 1", which transmitted telemetry for 5 months. Later, in December 1958, they launched a satellite named "Score" which transmitted a pre-recorded message from the US President. It too was launched into a polar orbit.

In 1960 the USA placed a large balloon, covered in metallised fabric and called "Echo 1", into a medium earth orbit to evaluate payload and launch vehicle options. Later that year the first "store and forward" satellite, named "Courier" was launched. That satellite stored messages on magnetic tape for retransmission later during the orbit.

In 1961, at the Paris Airshow, two Hughes aircraft Company scientists demonstrated the operation of the predecessor to the "Syncom 1" satellite atop the Eiffel Tower.



Syncom

In July 1962 the first private enterprise satellite was built by Bell Systems. Called "Telstar 1", it was a powered spaceborne repeater, placed in an elliptical orbit by NASA. This satellite proved the concept of using microwave repeaters for telecommunications from space to earth. Later in the same year, RCA built the "Relay 1" satellite, which was also launched by NASA, to investigate the transmission of voice, video and data from space.

The world's first geosynchronous satellite, "Syncom 2", was designed and built by the Hughes Aircraft Corporation in 1963, and in 1964 the world's first geostationary satellite "Syncom 3"was launched.

Syncom 3 had the capacity to relay either a single TV channel or 50 separate telephone conversations from an orbit high above the equator between Africa and South America. This position allowed it to relay the first real time TV transmissions between North America and Europe.

By 1965 the scientific community had realised that TV signals could be easily distributed over vast distances by using satellites in geosynchronous orbit as relay stations.

In 1965 the USSR had launched a domestic satellite communications system called Molniya (Russian for

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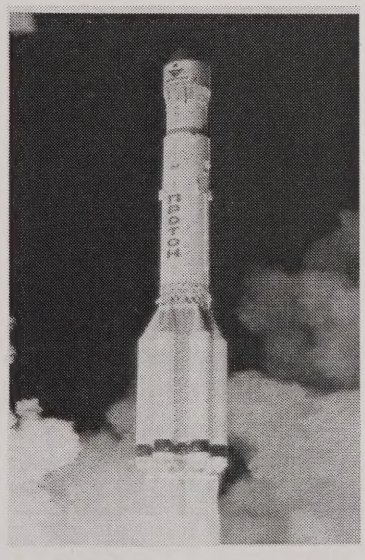
lightning). It connected isolated villages and towns throughout the Soviet Union with radio and television broadcasts originating from Moscow. Instead of using a geosynchronous orbit, the Russians deployed several satellites in elliptical orbits around the earth. As a result, ground stations had to constantly track the satellite as it passed overhead.

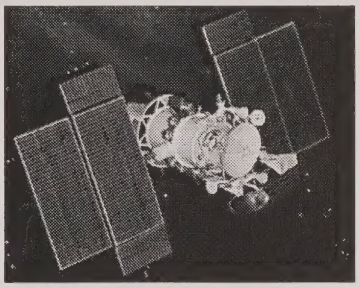
The Molniya orbit had a high northern apogee (usually around 40,000km), resulting in a reduction in the orbital velocity as the satellite travelled away from earth. The effect of this orbit was to place the satellites over northern regions for a longer period of time (compared with a geostationary orbit), in precisely the area where most coverage was needed.

The normal orbital period of these satellites was 12 hours, meaning that they were non-synchronous with the rotation of earth.



Proton launcher

Today the Molniya system has been replaced with a fleet of 10 Gorizont and Express satellites covering the major populated areas of the world. These satellites are operated by the Russian Space Agency, formed after the break-up of the former Soviet Union and the dissolution of the former Soviet Space program.



A Gorizont satellite

In 1966, the International Telecommunications Satellite Organisation (Intelsat) launched "Early Bird" into geosynchronous orbit over the Atlantic Ocean. It had the capacity to transmit 240 voice circuits or a single TV signal. However, since it employed an omni directional antenna, a large proportion of the available energy was radiated in directions where it could not be used.

In order to keep the satellite antenna oriented in the correct plane for transmitting towards earth, the cylindrical body of Intelsat 1 was spun on its axis at a fixed rate. This "spin stabilisation" technique was subsequently adopted by most other satellites.

By the late 1960's, Intelsat had devised a system where spin stabilised satellites were given orbital assignments over the Atlantic, Pacific and Indian Oceans to cover the entire globe. By this time the capacity had been increased to 1500 simultaneous voice circuits and 1 TV circuit. In addition, these satellites carried directional antennae so that the full available power was radiated towards earth.

Subsequent Intelsat satellites developed in the 1970's carried steerable spot beam antennas which were able to concentrate transmitted energy into powerful beams on desired areas of the globe. The capacity had been progressively improved and by 1975, 3750 telephone circuits and 2 TV channels could be carried simultaneously.

Today, major players Intelsat and Panamsat operate a combined fleet of 41 satellites around the world.

The latest series of Intelsat satellites allows provision of over 80,000 telephone channels, has a lifetime of 7 to 15 years.

International operation of Intelsat satellites occurs in four main areas:

The Atlantic Ocean Region (AOR) serves most of the Americas, Western Europe, India and all of Africa. Satellites in this region provide operational coverage from 222°E to 84°E.

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The Indian Ocean Region (IOR) covers India to Japan and Australia. Satellites in this region provide operational coverage from 60.5°E to 176.5°E.

The Pacific Ocean Region (POR) covers South East Asia, Australia, the Pacific and Western parts of Canada and the USA.

The Asia Pacific Region (APR) covers Africa, Asia and Australia. Traffic is highest in the AOR, almost double that in both the POR and IOR, and lowest in the new APR.

Intelsat policy is to provide multiple operational satellites in the AOR, IOR, APR and POR. In addition, there is one in orbit spare in each region. From time to time in orbit spare satellites are allowed to "drift" to alternative locations to replace earlier, and ageing satellites.

There are a number of privately owned companies operating satellites around the world. Originally an organisation comprising signatories from several countries, Intelsat grew over the 35 years from 1966 until July 18 2001 when it became a private company with over 200 shareholders.

Intelsat offers 4 types of beam coverage. A "global" beam covers almost one third of the earth's surface. A "hemi" beam covers approximately one sixth, a "zone" beam covers a large landmass and a "spot" beam covers a specific area.

Panamsat is also a privately owned satellite company with spacecraft covering the POR, IOR, and Latin America. The company has plans to expand the number of operational satellites around the world to 24.

In Australia, Singtel-Optus Communications owns and operates 4 geostationary satellites: Optus B1, A3, B3 and A2.

These satellites provide Remote Area Broadcasting Service (RABS) (previously called HACBSS-Homestead and Community Broadcasting Services) to remote areas, carry interchange links for commercial TV networks, commercial services, Pay

Table of significant launch dates in Satellite History

1957	October 4	Sputnik 1	First Satellite in space
	November 3	Sputnik 2	First creature in space
1958	February 1	Explorer 1	First US Satellite in space
	December 18	Score	First telecommunications satellite
1959	October 13	Explorer 7	First meteorological satellite
1960	October 13	Explorer 8	First NASA Satellite in space
1962	February 24	Echo 1	First TV broadcast by Satellite
	April 26	Ariel 1	First UK Satellite in space
	July 10	Telstar 1	First commercial telecommunications Satellite
	September 29	Alouette 1	First Canadian Satellite in space
1964	August 19	Syncom 3	First geostationary telecoms Satellite.
	December 15	San Marco 1	First Italian Satellite in space
1965	November 26	Asterix	First French Satellite in space
1967	November 5	ATS-3	First geostationary meteorological Satellite
	November 29	Wresat	First Australian Satellite in space
1968	May 17	ESRO 2B	First European Satellite in space
	November 8	Azur	First German satellite in space
1970	February 11	Ohsumi	First Japanese Satellite in space
	April 24	Dong Fang Hong 1	First Chinese Satellite in space
1974	August 30	ANS	First Dutch Satellite in space
	November 15	Intasat	First Spanish satellite in space
1975	May 19	Aryabrata	First Indian Satellite in space
1976	July 8	Palapa A1	First Indonesian Satellite in space
1978	October 24	Magion 1	First Czechoslovakian Satellite in space
1981	April 12	Space Shuttle STS 01	First re-usable space vehicle
	August 7	Intercosmos Bulgaria 1300	First Bulgarian Satellite in space
1984	April 6	SMMShuttle	First Satellite repair in space
	November 16	STS 19	First Satellite returned to earth for repair
1985	February 8	Brazilsat A1	First Brazilian Satellite in space
	June 17	Morelos 1	First Mexican Satellite in space
1986	February 22	Viking	First Swedish Satellite in space
1988	September 19	Offek 1	First Isreali Satellite in space
	December 11	Astra 1	First Luxembourg Satellite in space
1990	January 22	Lusat	First Argentinean Satellite in space
	July 16	Badr A	First Pakistan Satellite in space
1992	August 10	Kitsat A	First S.Korean Satellite in space
1993	September 25	Posat	First Portuguese Satellite in space
	December 18	Thaicom 1	First Thai Satellite in space
1994	August 10	Turksat 1B	First Turkish Satellite in space
1995	August 31	Sich 1	First Ukrainian Satellite in space
	August 31	Fasat Alfa	First Chilean Satellite in space
1996	January 12	Measat 1	First Malaysian satellite in space
1997	May 20	Thor 2	First Norwegian satellite in space
	August 19	Mabuhay 1	First Philippine satellite in space
1998	April 30	Nilesat 101	First Egyptian satellite in space
	Aug 25	ST-1	First Singaporean satellite in space
1999	Feb 22	Orsted	First Danish satellite in space
	Feb 22	Sunsat 1	First South African satellite in space
2000	Sept 26	Saudisat 1A	First Saudi Arabian satellite in space
	Oct 21	Thuraya 1	First UAE satellite in space

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TV, Civil Aviation voice circuits and many digital radio, and data services.

The A series spacecraft has been replaced by the B series spacecraft, which have higher power capability and tighter footprints. The first of the C series satellites was launched mid 2003.

The 1996 World Satellite Yearbook listed 123 operational satellites distributing television and radio around the world.

By 2001 there were 245 operational TV satellites in orbit.

TVRO History

TVRO (TV receive only) history is short. Prior to 1975 there was simply no private reception of satellite TV signals.

Electronics enthusiasts and amateur radio operators have long played an important role in the development of TVRO systems. In 1975 a British experimenter, Steve Birkill pioneered the construction of home made dishes, microwave amplifiers and receivers for satellite TV reception.

In the USA, enthusiasts Bob Cooper and Taylor Howard were busy developing techniques and modifications to allow surplus military equipment to be pressed into service, and consequently, a group of 30 or so radio amateurs began the "Home Satellite TV" industry in the UK and USA.

The 1980 issue of the American magazine "Radio Electronics" featured a series of instructional articles, showing the progress made by radio amateurs in pursuit of this new hobby.

Australia has its pioneers too, like Vic Barker VK2BTV, who pioneered the reception of Intelsat 3 in the mid 1970's using low threshold techniques the experts thought impossible.

In 1980 another Australian enthusiast, Fraser Hickox and American Taylor Howard formed an

alliance to bring the first satellite TV signals to the general public in outback Australia. They constructed huge spherical antennas to receive Intelsat 4, bringing the American Armed Forces TV and Radio Service (AFRTS) and the Australian ABC to outback residents.

These signals were subsequently terrestrially re-broadcast by VHF transmitters, located at remote communities. Later, the huge spherical antennas were replaced with more manageable 3.7m fibreglass dishes, produced in Brisbane.

Hundreds of these dishes served remote communities and homesteads until the successful launch of the first Aussat satellite in 1985.

In New Zealand, the first large (3.7-6 metre) TVRO

Spherical dish in outback Australia

dishes were manufactured and installed in the South Canterbury area by Gary Fogarty in 1983. The sole source of signals came from the Intelsat "bird" at 180° east. As the government run VHF terrestrial TV service operated a single channel for very few hours each day, a market soon emerged for the supply of C band equipment capable of bringing AFRTS and several US network feeds into homes and motel rooms across New Zealand and the "nearby" Chatham Islands, 600 kilometres away!

Roger Keen, another pioneer, installed numerous tracking systems at isolated mountain resorts along the West coast, and around New Zealand, and in 1989 installed the first re-transmission system for satellite TV signals on the

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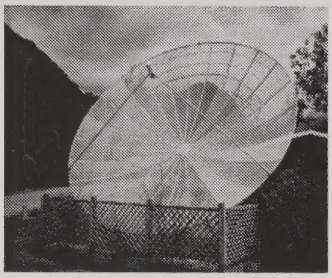
Chatham Islands, used until the mid 1990's.

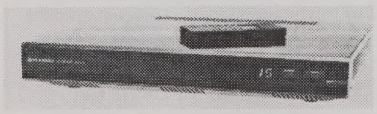


Chatham Islands dish

In July 1985, after successfully evaluating reception from an early "Anik" satellite, (moved from its orbital assignment over Canada for several weeks of testing), Australia launched Aussat A1, a Hughes 376 spacecraft with 15 transponders. This satellite was to be specifically used for television distribution across Australia and New Zealand.

Subsequently, Aussat A2 and A3 satellites were launched in November 1985 and September 1987 to cater for additional demand and future expansion.

Early DBS systems used a 3m dish, 2dB (noise figure) LNBs and a B-MAC receiver, locally produced under license from Scientific Atlanta (Canada), and made by Plessey Australia. At an installed cost approaching $3000, such a system was capable of delivering two channels of TV and radio programming.

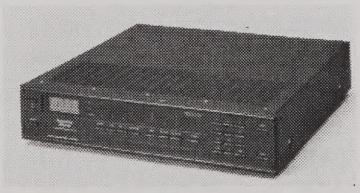


In total, some 18,000 Plessey BMAC receivers were sold into the outback and nearby Pacific island markets, such as Norfolk and Lord Howe Islands, New Guinea, New Zealand, Samoa, and New Caledonia.

Although notoriously unreliable in tropical conditions, a Plessey 2001 receiver commanded a substantial price until the end of the product life.

The replacement BMAC receiver, purchased out of necessity when Plessey discontinued manufacturing in the mid 1990's, came from Canadian company Scientific Atlanta, the original license holder of the proprietary BMAC system.

The 625 line BMAC receiver, model 9708 was a rack mounted commercial unit had no remote control facility. In addition, the radio services that were accessible in a standard 2001 receiver, required an additional audio decoder board to be fitted to the #9708, costing around $600.



Scientific Atlanta #9708 BMAC decoder

In 1991, Av-Comm Pty Ltd became the first to market a Ku band system, capable of receiving the PAL interchange signals on the Aussat A1 satellite, for less than $1000.

Although these signals were weak, and certainly not originally intended to be received by backyard enthusiasts, LNB technology in particular had improved to such an extent by that time that a 1.6m dish could be used for good reception !

Several thousand systems were sold, opening both a new world and market of satellite enthusiasts.

Now, private individuals whose terrestrial television reception was poor or non-existent, had an additional source of entertaining "signals", despite their fortuitous nature.

In other parts of Australia, C band signals from international satellites were becoming available, first from several Russian "Gorizont" spacecraft, then from the Indonesian Palapa B2P satellite.

Intelsat also increased the number of operational satellites in the POR (Pacific Ocean Region) to 4, resulting in an increase in occasional signals for enthusiasts, in all parts of Australia, not just the far north.

In July 1995, Panamsat launched the PAS-2 satellite covering the Pacific Rim, initially providing up to 5 analogue fortuitous, FTA (free to air) signals, capable of being received all over Australia using dishes in the 1.8m to 2.3m range.

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Later in 1995, the now inactive operator Rimsat, commenced operations using two Gorizont class satellites, whose footprints covered Australia and New Zealand.

In November 1995, Asiasat 2 was launched, covering Australia with C band signals strong enough to be received using dishes from 3m down to 1.8 m.

Several broadcasters took advantage of this satellite to broadcast channels collectively known as the "European Bouquet", across Asia and the Pacific. The service is still running today.

On February 15 1996, Palapa C1 and subsequently Palapa C2 were launched as replacement satellites for Indonesia. The C generation Palapa satellites operated by Satelindo, are the third generation of Palapa satellite, built by Hughes Aircraft USA, and offer wide coverage over the Pacific Rim.

Coverage extends from Iran to Vladivostok and further south to both Australia and New Zealand, providing up to 20 "fortuitous" signals for enthusiasts.

In 1998 PanAmSat launched Panamsat 8, and Panamsat 10 in 2001. These satellites also provided enthusiasts with fortuitous free to air signals.

In 1999 Asiasat 3 was launched providing a multitude of free to air channels provided by Asian and Indian broadcasters.

In April 2003 Asiasat 4 was launched covering 40 countries with its huge footprint.

In June 2003 the Optus C1 satellite was launched. This is the first of a series of third generation satellites for Australia's domestic services. Already plans are well underway for the production and launch of Optus D1.

The list of future satellite launches continues to grow.

Since 1985, the number of satellites visible to Australia, providing entertainment quality signals, has increased to over 10, resulting in increasing interest in home satellite TV reception.

In fact, the satellite orbital data section at the end of this book now lists over 55 satellites having a footprint covering some part of Australia.

The introduction of digital compression has allowed a huge increase in the number of channels able to be received.

Because of the reduced cost per channel to the broadcaster, and the lower hardware cost associated with mass production for the potentially huge audience, some countries have shifted their overseas broadcasting emphasis from short wave to satellite broadcasts.

Often, satellite signals are broadcast in foreign languages: NHK Japan, RTPI Portugal, Deutsche Welle Germany, CCTV4 China, Arirang TV Korea, TGN Thailand (to name a few), making them an important source of international programming.

There are now over 30 countries broadcasting satellite TV signals into the Pacific.

Schools and Universities can utilise these signals for language tuition, hotels can offer foreign language channels to their international guests, immigrants and expatriates can keep in touch with their country of origin, and potential tourists can see what life is like in other parts of the world, without leaving home.

Presently there are over 250 satellite signals in most languages of the world available free to satellite enthusiasts in Australia.

Principles of Operation

Geosynchronous and Geostationary Orbits

A geosynchronous satellite is one which orbits at the same speed as the earth. This means that the time taken for a geosynchronous satellite to complete one orbit in space is the same as the time taken for earth to rotate once on its axis. It also means that the satellite orbits in the same direction as the rotation of the earth.

A geosynchronous orbit does not mean that the satellite will remain in the same position above earth. It will move north and south of the equator during its orbit. A geostationary satellite has zero inclination, and hence remains above the equator at all times during the orbit, at an altitude of about 36,800km (22,280 miles). This is the most widely used type of satellite orbit because elaborate tracking systems are not required.

During the seventeenth century Johannes Kepler derived three laws describing planetary motion which were later verified by Newton. Basically, Kepler's laws apply to any two bodies in space that interact through gravity. These laws set the parameters under which geosynchronous orbit can be achieved.

The period taken for a geosynchronous orbit is 23 hours 56 minutes. This is about 4 minutes shorter than a twenty-four hour day, the difference being attributed to the movement of the earth around the sun. An exact geostationary orbit cannot easily be obtained in practice due to solar gravity and the effects of the earth's equatorial bulge.

This means that the orbital parameters vary with time. The gravitational forces of the moon and the sun produce a shift of around 1 degree per year in inclination, and the equatorial bulge causes a drift in an easterly direction.

As the earth is not perfectly circular in the equatorial plane, there is a small eccentricity, in the order of 10-5, called the "equatorial ellipticity".

In addition, the plane of the equator does not lie in the same plane as the earth's orbit.

The seasons experienced on earth are a direct result of this. With respect to earth, the sun slowly moves from 23 degrees above the equatorial plane (the winter solstice) to 23 degrees below the equatorial plane (summer solstice) and back again over the course of one year. Geostationary satellites experience the same effect, reducing the amount of energy available from the spacecraft solar panels during the two equinoxes.

A further effect of all this is to cause a gravity gradient affecting orbiting satellites. The gravity gradient causes "out of life" geostationary satellites to drift to one of two stable points, which coincide with the minor axis of the equatorial ellipse.

These two points are separated by 180 degrees, and lie at approximately 75 degrees east and 105 degrees west longitude, and are known as satellite "graveyards".

As an indication of the congestion in space, the US Space Command routinely tracks over 8700 objects over 10cm in diameter, and over 400,000 pieces of debris over 5cm in diameter.

By early 2001 there were more than 840 satellites and rocket upper stages in or near geostationary orbit, even though only 242 of these spacecraft were operational and under ground control.

There are now over 100 older satellites that have been left in orbit at the end of service. Without the benefit of station keeping fuel, all these and the 600 odd significant pieces of debris, will eventually drift to the graveyards of 75 E and 105 W.

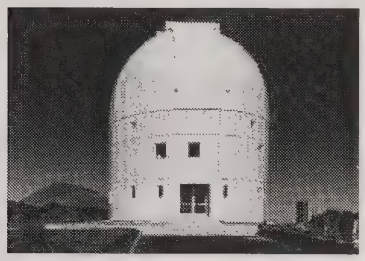
Geostationary satellites must be constantly monitored to ensure they remain at zero degrees inclination to the equator and in a circular orbit.

All satellites are at significant risk of collision with space junk, and there is an urgent requirement to be able to predict the location of satellites and junk alike at a particular time.

At present, most space surveillance is performed by the US and the European Space Agency. The US Space Surveillance Centre operates inside Cheyenne

Mountain near Colorado Springs, and processes both optical and radar data on more than 8500 objects.

The European Space Agency operates a facility at the Teide Observatory in Tenerife (Canary Islands, Spain). This facility is able to optically view objects down to 1 meter in diameter.



Teide Observatory, Tenerife

The major concern with space debris is that it might damage an operational satellite. Even a particle 1cm in size, orbiting at 8 Km per second could destroy a communications satellite.

At least one satellite and a rocket upper stage are known to have exploded in geostationary orbit.

A further hazard relates to nuclear powered satellites. Up until 1989, Russia had launched 31 nuclear powered satellites into low earth orbits (250-300 Km). At the end of the satellite mission, the accepted procedure was to boost the reactor into a higher orbit (around 1000 Km), where it should remain for thousands of years.

However, the sophisticated "Haystack" radar used to monitor small pieces of space debris, indicates that some reactors are leaking liquid Sodium-Potassium alloy. This leakage is in the form of droplets up to 5cm in size, and current estimates are that there may be over 200,000 droplets in orbit.

Nuclear power sources are part of the general problem of space pollution. The use of nuclear power sources is regulated by the United Nations.

Keplerian elements

Earth orbiting satellites are defined by six orbital elements called Keplerian elements. Two of these elements, called the "semi-major axis" and the "eccentricity" define the shape of the orbit. The third element called the "mean anomaly" gives the position of the satellite in its orbit at a reference time called the "epoch". The fourth element is called the "argument of perigee", and gives the rotation of the perigee point of the orbit relative to the line of nodes in the earth's equatorial plane. The remaining two elements, called the "inclination" and " right ascension of the ascending node" relate to the plane of the orbit relative to earth.

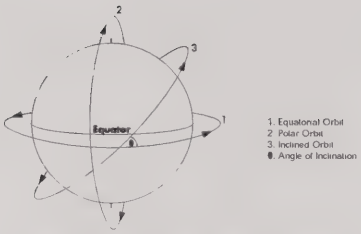
Two line element sets are regularly published to allow accurate predictive pointing of satellite dishes. The elements are maintained by NORAD and are available from various Internet sites. The two-line element set comprises two 69-character lines of data, which can be used with NORADs orbital model to determine the position and velocity of a specified satellite at any time. A further discussion into the mathematics is beyond the scope of this book. However the 2 line set allows the casual observer to determine the satellite (NORAD) number and year of launch, and hence identify an unknown satellite.

Orbit types

A satellite remains in orbit because the centripetal force caused by its rotational velocity is counter-balanced by the earth's gravitational pull. The closer the satellite is to the earth, the greater the gravitational pull and hence the higher rotational velocity required to keep the satellite in orbit. Geostationary satellites travel at 11,000km per hour with a rotational period of 23 hours 56 minutes, the same as that of the earth. They need to remain at that rotational speed to orbit at 36,800km.

Lower altitude satellites (160km to 450km) travel at approximately 28,000km per hour and take about 1.5 hours to circle the earth. Medium altitude satellites (9,000km to 19,000km) have rotational intervals of 5 to 12 hours.

Principles of Operation



Prograde & retrograde orbits

Non-synchronous satellites rotate in low altitude, elliptical or circular patterns, with the earth as a focal point, and with an angular velocity either greater than (prograde) or less than (retrograde), that of earth. They do not appear stationary in their sky position to a fixed point on the earth's surface and therefore expensive tracking equipment is required to follow and communicate with these satellites.

Also the communications interval is limited to a short period of time whilst the satellite remains within reasonable viewing angles and tracking limits.

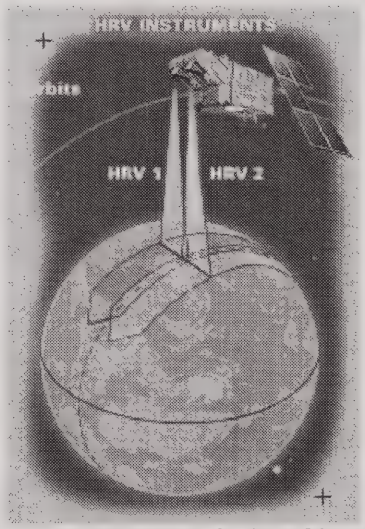
Polar orbit

A polar obit is one in which a satellite travels in a north-south direction rather than the east-west direction in which the earth and geosynchronous satellites rotate.

A polar orbit is useful for viewing the surface of the earth, and as a result remote sensing and weather satellites commonly use this type of orbit. By travelling in a north-south direction as the earth rotates in an east-west direction, very thorough coverage of the globe can be achieved.

Most polar orbiting satellites maintain an altitude of 1000km and an orbital rotation period of 100 minutes. For the last 20 years the USA has provided continuous meteorological information from its series of NOAA polar orbiting satellites.

Russia has also maintained a series of Meteor satellites in polar orbit.



Typical example of polar orbit

Sun-synchronous orbit

A derivative of the polar orbit is the Sun synchronous orbit

As previously mentioned, the earth is not a perfect sphere (it bulges at the equator), and any orbit passing over the geographic poles is asymmetrically affected by the gravitational pull at the bulge. The result of this affect is to slowly rotate the plane of the orbit about the axis of the earth. When the inclination is carefully selected (approximately 8 degrees off the polar orbit) the motion matches the motion of the Sun across the sky, and the plane of the orbit remains fixed.

A satellite in Sun synchronous orbit maintains the same positioning between satellite and the Sun so that the area the satellite covers always gets the same sunlight angle.

This has significant advantages where remote sensing applications require consistent coverage of the same area on a regular basis.

Geostationary orbit

The primary advantage of a geostationary satellite, is that it remains almost stationary with respect to a given point on earth and consequently tracking equipment is not required.

High altitude geostationary satellites can cover a much larger area of the earth's surface than low orbiting types, and hence three geostationary satellites can cover 90% of the entire globe.

There are, however, some disadvantages. High altitude geostationary satellites introduce noticeable propagation delays due to the distance that signals must travel. A two-way telephone conversation is delayed 500mS.

Geostationary satellites require higher transmit power than the lower polar orbiting types, requiring larger battery and solar cell

capacity, limiting the life of the spacecraft. In addition, greater transmission losses associated with a longer path, ensure that large dish antennas are required on earth to receive signals.

Geostationary satellites used for remote sensing applications have some particular limitations. Whilst capable of providing coverage of large areas over the equator (42 percent of the surface of the earth), geostationary satellites can only provide distorted images of the polar regions with poor spatial resolution.

In fact, points on the earth having a latitude of greater than 81 degrees are not visible to geostationary satellites. This is why satellites in geostationary orbits are not generally used for remote sensing applications.

Most importantly, geostationary satellites must be kept in the correct orbit. Station keeping requires the use of hydrazine propulsion rockets. There is a limit to the amount of this fuel that can be carried on board each spacecraft. Presently, this is the limiting factor determining satellite lifetime.

It is unlikely in the future that such satellites will be refuelled by manned spacecraft, due to the distance that must be travelled to get to a geostationary satellite.

The inclined orbit

Inclined orbits are those that have an inclination between zero degrees (geostationary) and ninety degrees (polar orbit). These orbits are determined by the required area of coverage, or by the latitude of the launch site. The orbital inclination of a geostationary satellite would vary by about 0.85 degrees per year if left uncorrected. After 26 years of not being corrected the satellite would arrive at an inclination of about 15 degrees. From that point the inclination begins to decrease so that after another 26 years the satellite would be back at zero degrees of inclination, i.e. geostationary.

Sometimes a satellite will be deliberately launched into an inclined orbit to cover a particular area of the world.

The early Russian Molniya satellites utilized an orbit having 65 degrees or inclination, giving an elliptical 12-hour orbit over northern USSR.

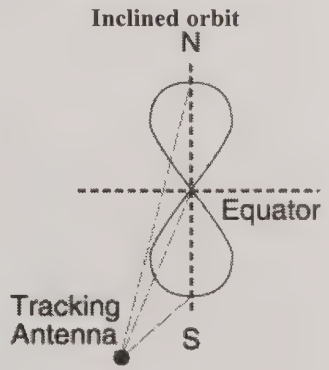
Satellites can also end up in an inclined obit due to failure of the launch vehicle. There have been some spectacular examples of recovery from highly inclined orbits in the last 5 years.

In September 1988 GSTAR 111 was launched. Several days after launch the AKM fired without command placing the satellite into a highly inclined orbit. Over the next year ground controllers made over 160 controlled thruster "burns" to return the satellite to geostationary orbit.

More recent is the case of the original Asiasat 3 satellite, launched on December 25 1997, aboard a Proton launcher from Baikonur. The upper stage of the launcher fired for just one second, instead of the scheduled 110 second burn required, leaving the satellite in a highly inclined orbit—a total commercial loss.

Engineers from Hughes Global Services devised a method of catapulting the satellite around the moon twice over a period of several months, and by strategically firing rocket thrusters on over a dozen occasions, bought the satellite back into geosynchronous orbit with only a slight inclination. That satellite, renamed HGS-1, and located at 174 W longitude, is now a commercial success.

Similar results have been achieved by the same company with Palapa C1 (renamed Anatolia-1, now serving Turkey), and Chinasat 7 (renamed HGS-2), launched in August 1996.



Principles of Operation

The Space Segment—the downlink.

There are two commonly used bands for down linking satellite TV signals. C band (3.4-4.2GHz) and K or Ku band (10.95-12.75GHz).

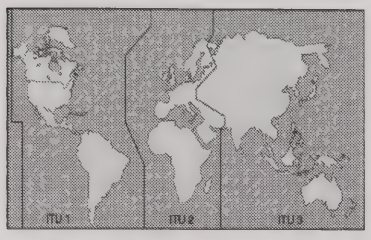
C band is utilised by satellite operators wishing to cover a large area with a relatively weak signal, requiring a large receiving dish. Traditionally these are international signals.

Ku band is used by satellite operators who require a strong concentrated signal covering a dedicated area on earth. This is generally reflected by the use of higher satellite power, resulting in the use of smaller receiving dishes on earth. Generally Ku band is used for the distribution of domestic satellite programming.

These bands are geographically set by international convention.

The world has been divided into three separate regions, by the ITU (International Telecommunications Union) for the purposes of allocation of all radio (and satellite) frequencies. These frequency bands are allocated on a non-interference basis.

Region 1 covers Europe, Africa, the former USSR, and Mongolia. Region 2 covers North and South America and Greenland. Region 3 covers Southern Asia, Australia and the South West Pacific.



ITU regions of the world

Within these regions, frequency bands are allocated for different types of satellite services. Some of these services are Fixed Satellite Services (FSS), Direct Broadcasting Services (DBS) or Direct to Home Services (DTH), Mobile Satellite Services, Meteorological Services, and Navigation Satellite Services (such as GPS).

Countries wishing to reserve orbital positions for the location of geostationary satellites must do so with the ITU. As 2 degree spacing has been adopted, this means theoretically there can only ever be 180 satellites in separate geostationary locations at one time.

In practice, this is not strictly true. There are many countries that are not signatories to the ITU, who have launched and positioned satellites at orbital locations without any consultation with other satellite operators or the ITU.

Also, it is often possible to co-locate more than one satellite at the same orbital position. The satellites remain some distance apart (perhaps one tenth of a degree), but the "nominal" orbital location is the same.

On board spacecraft radar, and tight ground control can allow as many as 10 satellites to be co-located at the same nominal orbital location. As an example, there are presently 7 satellites co-located at 19.2 degrees east, serving Europe.

At present there are almost 650 geostationary satellites in orbit, although not all are used for television delivery services.

The ITU presently has a backlog of some 1200 applications, and this figure is increasing at the rate of 400-500 per year.

This problem, known as the "paper satellite" problem, has been created by countries wishing to cash in on the limited orbital assignments available, and continues to be a problem.

Launch techniques

Satellites may be launched using either of two presently available systems. Launch vehicles such as the Space Shuttle are classed as reusable, whilst Atlas, Delta, Proton and Ariane are classed as expendable.

Both these types of launch vehicle are commonly used to place the satellite in a low earth orbit of 200km or so. In the case of the Shuttle, once 200km altitude has been reached, the satellite is unloaded from the cargo bay, spun to stabilisation speed and a small rocket motor called the perigee kick motor (AKM) is fired to propel the satellite into a transfer, and

subsequently the higher final orbit.

The initial inclination is 28.5 degrees and this needs to be reduced to a value of 0 degrees as well as achieving an altitude of 36,800 km, at the final orbital location over the equator.

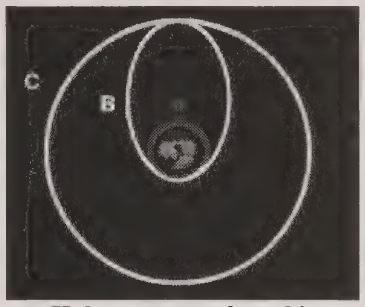
In the case of an expendable launcher, the first stage propels the satellite into low earth orbit, and the second and third stages are used to transfer the satellite into a higher orbit.

As a significant amount of energy is required from the launch vehicle to place a satellite into orbit, and as this cannot be done in one operation, an energy conserving intermediate "transfer" obit is utilised between the initial low earth and the final high altitude orbit.

The Hohmann transfer orbit, otherwise known as the geostationary transfer orbit (GTO) is a fuel-efficient method of transferring from one circular orbit to another circular orbit in the same plane or inclination but at a different altitude.

This is done in practice by firing a rocket engine in the direction to the direction of travel, adding velocity and causing the obit to become elliptical. The elliptical orbit is designed to have the same final altitude as the final orbit. Two parameters have been changed in this process, the altitude and inclination.

When the final altitude is reached, the rocket engine is again fired, adding the necessary velocity to change the elliptical transfer orbit to the new circular, and final geostationary orbit. All this relies on several engine firings at precisely the right timing, in precisely the right direction to produce the exact velocity change to create the new orbit.



Hohmann transfer orbit

Launch sites

It can be mathematically shown that the smallest (most desirable) inclination that can be achieved at launch from any site is equal to the latitude of the launch site. Therefore satellites launched from sites closer to the equator require less energy to achieve a higher orbit than sites at latitudes remote from the equator.

This is why Ariane has a launch site at Kourou in French Guiana (latitude 5.20N).

Since 1999 a new launch company "Sea Launch" has been operating the Boeing Sea Launch platform, a converted Norwegian offshore oilrig at Christmas Island (latitude 3.0 degrees N, longitude 157.0 degrees W). To date they have successfully launched 8 satellites.

The company is made up of a consortium comprising: Boeing Commercial Space Company (USA), Kvaerner (Norway), RSC-Energia (Russia) and SDO Yuzhnoye/PO Yuzhmash (Ukraine).

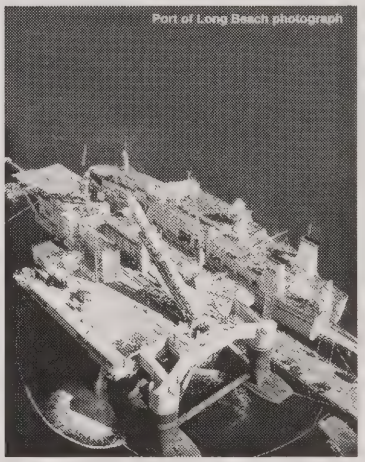


photo:www.sea-launch.com

The company uses Zenit-3SL for stages 1 & 2 and the Energia produced DM-SL stage 3 rocket. This combination gives a launch capability of 6000 kg.

The Russian Space Agency (RSA) uses technology and launch sites that belonged to the former Soviet space program. The RSA has centralised control of Russia's civilian space program including all manned and non-manned non-military space flights.

Most launches are conducted from the Baikonur Cosmodrome, located near the city of Leninsk, which was established in 1955, two

years before the launch of Sputnik 1.

In 1991 the Kazakh Soviet Republic broke away from the former Soviet Union and formed the independent nation of Kazakhstan. The Cosmodrome fell into chaos, primarily over the disputes regarding Russia's lease payments.

In 1993 Lockheed Corporation formed a joint venture with the Khrunichev State Research and Production Space Centre and RSC Energia, to market Russia's heavy lift vehicle, the Proton.

Most Gorizont satellites presently in orbit were launched using the 4-stage Proton medium lift launcher, first introduced in 1965.

In 1995 Lockheed merged with Martin Marietta and a new venture was formed called International Launch Services.

This company markets launches using Proton and Atlas launch vehicles. The success of the venture has led to huge improvements in the facilities at Baikonur. The Cosmodrome is now used to launch not only Russian satellites, but has also been used to launch satellites operated by PanAmSat and Optus, amongst others.

The RSA has entered into agreements with USA, France, Canada, China, India, Bulgaria, Hungary, Israel and the European Space Agency.

Satellites launched from Russia require far more energy from the launch vehicle because they are so far north of the equator. Kazakstan is located at latitude 45.6 degrees N, longitude 63.26 degrees E and has a minimum inclination of 49 degrees.

China's main launch site is the Xichang Satellite Launch Centre located in Xichang, in the southwest province of Sichuan. The site is located at 28.1 degrees N latitude, 102.3 degrees E longitude and has similar latitude limitations to the Russian site at Kazakstan.

India has a national space program operated by the Indian Space Research Organisation (ISRO) with most launches being conducted from the Sriharkota Space Centre (13.8 degrees N latitude, 80.30 degrees E longitude) located on Sriharikota island.

Launches commenced in 1979 and have operated regularly since. The launch pad has facilities for the range of Indian launchers, including SLV, ASLV, PSLV and most recently GSLV (Geosynchronous Satellite launch vehicle). These satellites generally carry scientific payloads.

Ariane has launched most of the existing Indian built telecommunications satellites.

The Sriharikota Space Centre operates TT&C for the Insat series of satellites. Japan's National Space Development agency (NASDA) operates the Tanegashima Space Centre on Tanegashima Island about 650 km from Tokyo.

The site is used for static firings of solid rocket boosters and was used for the H2 program, cancelled in 2000. It is now being used for the development of the H3 launcher.

The United States operates many launch sites. Cape Canaveral, located in Florida (28.5 degrees N latitude, 81.0 degrees W longitude) has been used since 1958 for over 500 launches. The facility can accommodate Titan, Atlas and Delta launch vehicles.

The Kennedy Space Centre, located on Merrit Island, Florida has been used to launch and recover the Space Shuttle since the late 1970's. Where weather conditions for landing are below minima, the Shuttle can land at Dryden Flight Research Centre, Edwards Air force Base, California.

Launch vehicles

There are many different satellite types and configurations, all having different launcher requirements. Launchers are classified according to their lift capability.

Heavy lift launch vehicles are capable of orbiting satellites in the 5000 kg range and include Ariane 4 and 5, Proton D1, Titan III, Titan IV, Zenit, Zenit Sea Launch and the Space Shuttle.

Principles of Operation

Large launch vehicles can lift 2000-5000 Kg and include Ariane 44L, Long March LM-2E & 3A, and the Indian GSLV.

Medium launch vehicles have a maximum payload of 200 kg and include Delta II, Long March LM-3, and several smaller Russian vehicles.

Small launch vehicles are limited to 1000 Kg and include Pegasus XL, Cosmos, Rockot, SLV-3 and many others.

A new type of launcher being developed is the Single Stage to Orbit (SSTO), which is planned to become operational in 2006.

The satellite

The equipment carried on board the satellite is classified according to function. The "payload" refers to that equipment used to provide the service for which the satellite is being utilised. The "bus" refers to the spacecraft and its internal systems, used to provide power, orbital and attitude control, and the telemetry used to monitor the payload.

The satellite can be subjected to enormous variations in temperature due to radiated heat from the sun. As it is important to keep the electronic equipment operating within normal temperature limits, use is made of thermal blankets, shields, radiation mirrors and ground-controlled heaters to keep the spacecraft at a constant temperature.

In order to keep a satellite in operation, considerable ground based support services are required.

It is necessary to track the satellite at all times, monitor power consumption and other electrical parameters, and approximately every two weeks, to command changes to the satellite altitude to ensure the satellite does not drift from its correct orbital position. The satellite constantly transmits a telemetry beacon, allowing automatic monitoring of spacecraft condition, and location.

The satellite itself requires significant electrical power to operate, and this is normally provided by solar panels, either telescoping cylindrical units or panels that are stowed during launch and which unfold after final orbit has been attained. The spacecraft batteries are normally nickel hydrogen types, due to their superior power to weight ratio, although until the mid seventies, nickel cadmium batteries were used.

Most Russian satellites are high-powered models, and derive their energy source from an on board atomic reactor. This approach is not favoured by Western countries, due to the increased risk encountered upon spacecraft re-entry and consequent disintegration, at the end of the spacecraft life.

In 1978 an atomic powered Russian military

SATELLITE 'RADIATION' NOW SAFE

Satellite radiation in Canadian lake, scientists claim

Remains of nuclear satellite hunted

Nuclear threat from space

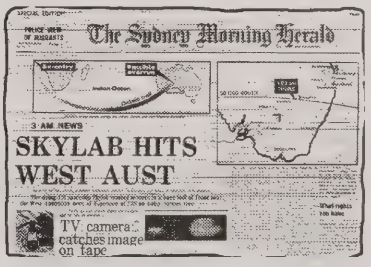
More satellites are using atomic power

No guarantees on radioactivity, says geologist

satellite, Cosmos 954 re-entered the earth's atmosphere, suffered partial disintegration and leaked radioactive material over northern Canada.

On July 11 1979, a large lump of the US Skylab space station crashed in outback Western Australia during re-entry into the earth's atmosphere. Fortunately no one was injured as debris fell to earth, however authorities in Esperance, W.A. issued the US State Department with a $400 fine for littering.

History repeated itself again on January 23 1983 when Cosmos 1402 re-entered the earth's atmosphere south of the islands of Diego Garcia.


The Sydney Morning Herald

3 AM NEWS

SKYLAB HITS WEST AUST

TV camera catches image on tape

The satellite nuclear reactor failed to separate from the spacecraft and could not be jettisoned into a safe orbit.

Principles of Operation

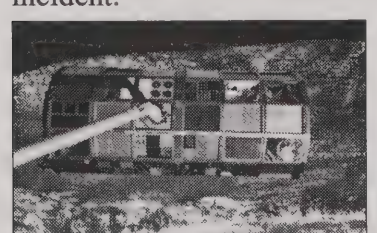
Fortunately the debris crashed harmlessly into the Indian Ocean.

The danger is not limited to the scattering or radioactive material. As a spacecraft re-enters the atmosphere, friction with the air causes intense heat and buffeting, tearing the spacecraft apart and showering pieces of metal on the earth below.

In another close call, the US Long Duration Exposure Facility (LDEF1) was deployed by the Space shuttle in April 1984. The mission was scheduled to last just 10 months, with an in orbit retrieval to be performed by the Space Shuttle. Various scheduling changes pushed the recovery to the end of 1985, and then the Challenger accident in January 1986 delayed recovery.

The 10-ton spacecraft had no fuel or engines, and ground controllers could only watch as the orbit decayed. By late 1989 the LDEF was coming dangerously close to earth.

Finally, in January 1990 the Space Shuttle Columbia took off on a rescue mission and recovered the spacecraft using the on board robot arm. NASA has not orbited this spacecraft type since the incident.



Long Duration Exposure Facility (LDEF) being retrieved by Space Shuttle after 5.7 years in orbit.

Attitude control

A significant proportion of the on board equipment is required to control the satellite attitude, independently of any earth based control systems. This is important as a number of forces can affect spacecraft attitude such as the gravitational pull of both earth and moon, meteorite impact, and the effect of solar radiation. Generally, infra red sensors are used to define the edge of the earth against the background of space. If multiple sensors are used, the centre of earth can be calculated as a reference point. Should the satellite orientation or attitude be disturbed, the horizon sensors will detect this and execute an attitude correction.

There are a number of methods of achieving spacecraft attitude correction. On geostationary spacecraft these include the use of hydrazine thrusters and momentum wheels.

Spin stabilisation

This stabilisation technique is used with cylindrical shaped satellites. The spin axis is aligned so that is parallel with the North/South axis of the earth. As long as the satellite has been constructed to be symmetrical, is can be spun on this axis at a rate ranging from 50-100 revolutions per minute. The spin is initiated during the final launch stage. Most footage of satellite launches from the Space shuttle show this rotation.

For communications satellites utilising directional antennae, the antenna platform must be de-spun using an electric motor. This involves bearings and a mechanism for transferring both power and RF energy.

Spin stabilisation can also be achieved in non cylindrical satellites through the use of momentum wheels. A momentum wheels consists of an electric motor, flywheel and bearing assembly all sealed in an evacuated housing.

The flywheel is coupled a permanent magnet which forms the rotor and provides a magnetic field. The stator is attached to the body of the satellite. The motor therefore couples the flywheel to the satellite.

By varying the current fed to the stator, the speed and torque can be adjusted. One indirect advantage of the single axis spin stabilised satellite is the averaging effect the rotation has on operating temperature, helping to balance the radiated heat from the sun against the cold of space.

Where multi axis stabilisation is required (yaw, roll and pitch) three momentum or reaction wheels are used.

Transponders

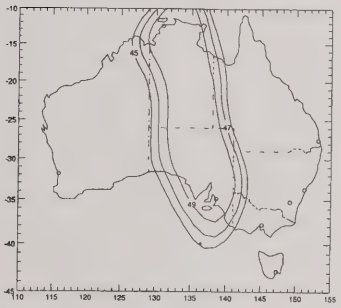
All satellites carry a number of individual repeaters comprising an

Principles of Operation

uplink receiver, coupled to a transmitter for down linking.

This combination is called a transponder. Most satellites carry between 15 and 40 transponders, which may be connected and cross connected to a number of directional dish antennas on the spacecraft, which point towards earth, targeting various areas with signal beams.

The most commonly encountered beams are global, covering a large area with reduced signal intensity, and spot beams which cover specific areas with higher powered signals. The diagram below shows a spot beam carried on the Optus B3 spacecraft.



Central Australian beam

The group of transponders normally operates in a 500MHz wide band, divided into sub-bands, one per transponder. Thus a satellite covering a band 500MHz wide could only accommodate 12 transponders having the required bandwidth of 36MHz each for analogue television quality signals.

Many more "virtual channels" can be accommodated using digital compression. There must also be a "guard" band of 4MHz between adjacent transponders to ensure that there is no interference, this reduces the transponder capacity even further. However, due to a frequency re-use technique using polarisation isolation, it is possible to accommodate 24 transponders, each 36MHz wide. Each adjacent transponder uses the opposite polarity (V or H).

Spacecraft C band uplink receivers operate on 6GHz, whilst K band receivers operate at 14GHz. There is considerable redundancy and duplication of equipment on board the spacecraft, to allow ground transponder switching arrangements in the event of a hardware failure.

The figure below shows the transponder arrangement on the "B" series of Optus Ku band spacecraft. Unlike terrestrial television, the transmission mode used by satellites for television, is FM (for both vision and sound).

FM is a transmission mode that requires a much lower amount of DC power when compared to AM, but does require a much wider bandwidth. So from the point of view of minimising spacecraft power usage, it makes sense to use FM.

However, one of the problems found when using FM for this purpose, is that if the spaceborne FM transmitter were allowed to remain on a single frequency for any appreciable time, interference would be generated to earth based services. This is easy to imagine, considering the EIRP of the average C band satellite is 2.5KW.

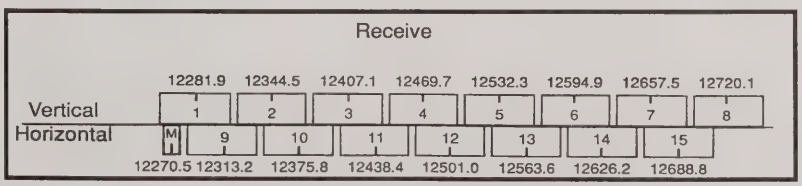
To ensure this kind of frequency interference can never be generated, a technique known as "energy dispersal" is used.

A sawtooth waveform is added synchronised to the field frequency, sweeping the video signal. An NTSC 525 line 60Hz signal uses a 30Hz energy dispersal signal, and a 625 line 50Hz PAL TV signal uses a 25Hz energy dispersal signal.

If the television signal occupies a full transponder, the dispersal level is held at 1MHz peak to peak deviation. If half transponder operation is used, the same dispersal level is used when video is present. When no video is present the level is increased to 2 MHz peak to peak.

This technique is particularly effective in eliminating interference, and is even used on terrestrial microwave link systems.

The energy dispersal waveform is removed in a



satellite receiver by clamping the video. The baseband output of most analogue satellite receivers contains unclamped and unfiltered video, and the effect of energy dispersal manifests itself as pronounced flickering of the video signal.

The antennas carried on the spacecraft must receive the uplink and transmit the downlink signals. The most common type of antenna used is the parabolic reflector. Generally there are a number of feedhorns used to illuminate each reflector. Each feedhorn is used to generate a special beam.

Typically footprint literature will describe these beams as global, spot or hemispherical, depending upon the coverage required.

Intelsat Global beams are used to cover large areas of land, and consequently have a lower signal level than Spot beams, which are designed to illuminate smaller and generally more populated areas. Hemispherical beams are similar in power to Global beams.

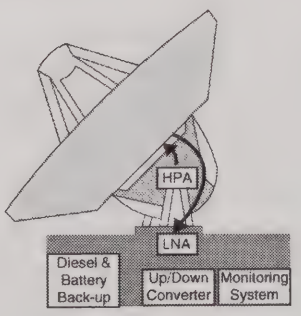
Typical footprint

The Ground Segment

The design of the uplink is significantly easier than the downlink since it is much easier to produce high power levels at ground based earth stations, than on a spacecraft.

However the construction is a costly exercise, as the generation of high stability, spurious free, microwave signals is expensive. In addition, larger dishes have a narrow beamwidth, so careful mechanical control of the dish is essential. If a smaller dish is used at the uplink, higher power levels must be generated to overcome the reduction in dish gain.

A typical uplink earth station comprises a dish antenna, feeder system, diplexer, transmitting electronics, transmit high power amplifier, a downlink monitor receiver, a tracking system and auxiliary systems required for power including generator back up, temperature control and antenna de-icing if necessary.



Typical uplink

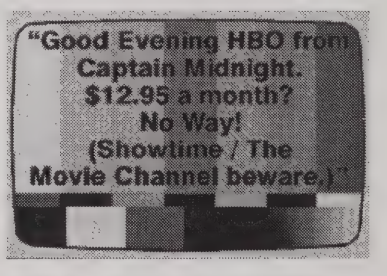
In addition there must be the interface circuitry between local microwave or optical fibre interconnects and the switcher controlling the transmitter.

Because a fixed uplinking station has the ability to transmit large amounts of microwave power into space, particular care must be taken to ensure that interference is not caused to adjacent satellites.

The international uplink band of frequencies for C band is 5.925-6.425 GHz, and for region 3 Ku band is 14.0-14.5 GHz.

An incorrectly aimed uplink could completely disrupt the services on an adjacent satellite. As the information transmitted to the satellite will be rebroadcast to potentially thousands of earth stations, a strict criteria for staff selection is employed.

In April 1986, an uplink operator, in Florida, USA calling himself "Captain Midnight", overrode an existing uplink program to broadcast his own message to viewers across mainland USA, protesting proposed scrambling of the HBO movie channel.



Due to the amount of uplink power at his disposal, he was able to completely obliterate the legitimate uplink signal on several occasions. He was finally tracked down through a

unique fault in the character generator at his uplink station.

Modern satellites require an encrypted security code to be transmitted to ensure only legitimate uplink stations have access.

Apart from uplinking the signal to be rebroadcast by the satellite, the uplink station is also responsible for TT&C (telemetry, tracking and command) functions, including station keeping.

The attitude of the satellite must be monitored and controlled and so must the orbital location. C band satellites must be kept within +/- 0.1 degrees or their orbital assignments.

The tolerance for K band satellites is even tighter at +/- 0.05 degrees.

This equates to keeping the satellite within an imaginary box in space measuring 150km x 150km.

To put things in perspective, satellites two degrees apart, are approximately 1525km apart in the geostationary orbit.

This operation requires a significant degree of accuracy when the uplink dish is large. Typically a 30m diameter uplink dish has a beamwidth of 0.1 degrees. This equates to a zone in space of only 75km in diameter, at an altitude of 37,000km. As the satellite can be anywhere within an area twice that size, care is required to ensure the position of the satellite is known at all times.

The Downlink

Equipment configured for reception of satellite signals on earth must take into account the satellite transponder power, bandwidth, and spacecraft antenna "footprint".

Each transponder can be connected to one of several spacecraft antenna. Each antenna has a separate "beam". A global beam is capable of covering up to 40% of the surface of the earth, whilst a spot beam can be concentrated on a specific area. Uplink operators can connect a particular satellite transponder to a particular antenna. They can also move the spacecraft antenna to change the coverage area.

The amount of power transmitted by a particular transponder is dependent on the uplink power to that transponder. Portable news gathering links with small antennas, can only operate at low power levels, so the corresponding satellite downlink will be low in power, requiring a large major earth station antenna.

A fixed uplink station is designed to deliver the correct amount of power to the satellite to ensure optimum downlink power. During times of heavy rain or snow, (which can attenuate both the uplink and the satellite downlink) the uplink transmitter must have sufficient power reserves to increase power to overcome the increase in path loss.

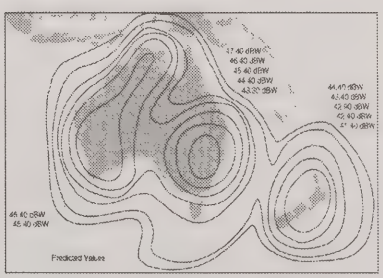
Link Budget Calculations

Due to the limited downlink power of the satellite, and the distance the signal must travel (and the corresponding path loss), it is important to select earth station components capable of producing a signal above threshold, for processing by the satellite receiver.

The two most important factors affecting the signal are the dish gain, and antenna/LNB noise temperature. To calculate the required performance of these two items, we must first know the level of the signal from the satellite as it falls on earth.

As satellites are designed to cover specific areas, a signal contour map, called a "footprint" is produced by the satellite owner, showing the signal levels that can be expected at particular locations on earth.

A footprint looks like a number of concentric circles, similar to the pattern generated when a pebble is thrown into a still pond. The circles closest to the centre have a higher energy level than the outer circles.



Pas-2 footprint

Note the higher strength signal contours closer to the centre or "bore sight".

Principles of Operation

The satellite EIRP (effective isotropic radiated power) can be read directly from the footprint. The ERIP contours are measured in units called the "dBw". A satellite output level of 20 dBw means that the power level of signal leaving the spacecraft downlink antenna is equal to 20dB , or 100 times one watt.

This figure is the product of the output power of the satellite transponder and the gain of the particular spacecraft antenna being used. Even if the footprint contours indicate a signal level of 50dBw, the amount of power actually reaching the surface of the earth (considering an average path loss of 200dB) is minute.

An analysis of the conditions affecting the loss of signal from spacecraft to earth, based on the EIRP, and the gain of the receiving antenna/LNB/feedhorn system, will then give us an indication of the C/N ratio (carrier to noise) arriving at the satellite receiver input.

This is useful in analogue systems, as the C/N ratio directly affects the video signal to noise (S/N) ratio produced by the satellite receiver.

This video S/N ratio itself means little to the consumer, so a subjective 5 point scale, called the CCIR scale has been devised as a practical method of subjectively evaluating the S/N ratio.

Quality	Characteristics	S/N
Exc (5)	Noise Free	46dB
Good (4)	Minimal Noise	42dB
Fair (3)	Noticeable Noise	38dB
Poor (2)	Annoying Noise	33dB
Bad (1)	Very Annoying	29dB

CCIR scale of quality

Terms

At this point it is useful to define some of the terms used to describe the performance of a digital system.

Bit Error Rate (BER) is the probability of (bit) errors over the downlink. A bit error rate of 1 x10-6 means there is a probability of one error in one million data bits sent over the downlink. So the ratio of erroneous bits divided by the total number of bits transmitted is the BER. This is a measurement of the performance result of a downlink.

Forward Error Correction (FEC) is the ratio of the number of bytes of information used to correct transmission errors, compared to the total number of bytes sent. A FEC of ½ means that one byte out of every two bytes is used for error correction.

This gives the best possible reception, at the expense of wasting bandwidth. For the best utilization of bandwidth and power a FEC ratio of 7/8 could be used. In this case a superior quality LNB, feed and dish is required to ensure the best possible reception, since only one byte in every eight sent is used for error correction.

The probability of reception errors also varies with program content. Fast moving sports programming requires many changes of picture information per picture frame, and hence the possibility of errors increases. However a TV presenter reading the news requires few changes of picture information per frame and hence the possibility of errors is reduced. So a FEC of 7/8 would be suitable for this application.

The Symbol Rate (SR) is the speed at which the digital signal is sent. The Symbol Rate includes the total bit rate, including the extra data for error correction.

As one symbol equals two bits, it is a simple calculation to work out the Bit Rate (BR) if the SR and the FEC are known.

For example, if the Symbol rate of a transmission is 30,800 and the FEC is ¾, the Bit Rate is…

30.8 x 2x ¾ = 46.2Mb/S.

The limiting factor is the available transponder bandwidth. As a general rule most transponders have a bandwidth of 36 or 54MHz depending upon the satellite configuration.

An approximation generally used is that the SR x 1.2 equals the bandwidth occupied by the signal.

Eb/No is a predictive tool used to determine the performance of a link. Eb/No is the energy per bit

to noise power density ratio. It is the ratio of a single bit to the noise power present in 1Hz of bandwidth. This effectively equalizes all digital modulation schemes to a common noise bandwidth. Eb/No is the equivalent to the analogue C/N ratio and is independent of the system data rate.

The steps to determine the downlink dish size are as follows:

Determine the Eb/No for the desired BER. This is determined by comparing the BER to the CCIR scale for picture quality.

Convert Eb/No to C/N at the receiver using the bit rate, then add the path loss and fade margins.

The table below shows the relationship between BER and CCIR quality.

BER	CCIR
10-6	5.0
10-5	4.8
10-4	4.0
10-3	2.4
10-2	1.0

It can be mathematically shown that for the QPSK A formula for calculating either the Eb/No or the C/N is available, however, this still involves complicated calculations. Fortunately, with the advent of the home computer, sophisticated software is now available to enable calculation of downlink budgets

One such program is "Sat master Pro", which sells for less than $200. An example of a link budget produced by Satmaster Pro

modulation system, commonly used in MPEG 2 satellite broadcasts, for a BER of 10-4 (the equivalent of CCIR grade 4) we need an Eb/No of 3.8 when using an FEC of ½ and an Eb/No of 4.6 when using an FEC of ¾.

One of the main factors affecting the attenuation of signal from spacecraft to earth is the free space path loss. Fortunately, this data is freely available, as can be seen in Fig 5a. In addition to this loss, the effects of rain need to be addressed.

In general terms, the higher the frequency, the worse the effect of rain on a satellite signal. Rain attenuation is worse at 12GHz than at 4GHz, and or course also affects the 6GHz and 14GHz uplink bands.

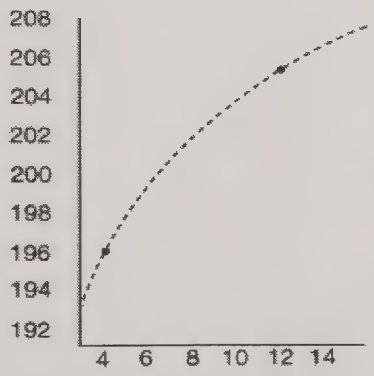
In order to compensate for the worst case of rain attenuation, to guarantee 100% reception reliability, the system designer might have to incorporate an extra 20dB of performance margin into an earth station.

Whilst this might be agreeable for commercial operators, the same criteria could not be applied to home systems, due to the higher costs involved.

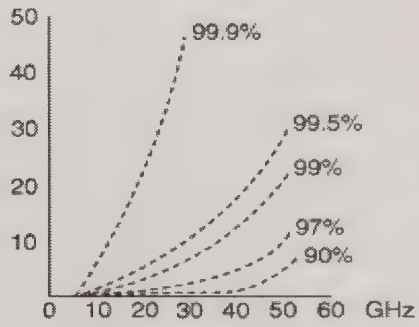
How this problem is overcome is by analysing the amount of time per year that heavy rainfall occurs, (usually relatively small), and by making calculations based on a "percentage availability" basis.

If the user can accept that the system will produce the desired signals for 98 or 99% of the time, and that during periods of heavy rainfall the received signal will be degraded, a far more cost effective system can be built. A larger antenna has higher gain, so if cost is no object a large antenna can be employed.

However a large antenna has a much narrower beamwidth than a small antenna, and this can make dish pointing much more difficult, especially at Ku band.



Path loss v Frequency



Attenuation v Frequency

is shown on this page.

In addition to calculating downlink budgets, this software has a huge geographic location database, allowing dish pointing coordinates to be calculated for most places on earth. There is also a comprehensive explanation of all functions, so the user can fully understand what parameters affect the downlink and why they are so important.

Downlink Analysis (1.6m Antenna)
Produced using Satmaster (Sunday, May 19, 1996)

Site name	Sydney
Satellite name	Optus B1
Summary of Input Parameters	
Site latitude	34S (degrees)
Site longitude	151.2E (degrees)
Magnetic variation	12.25E (degrees)
Site altitude	0.1 Kilometres
Satellite longitude	160E (degrees)
Spot beam polarisation cant	43.78 degrees
Channel/Transponder frequency	12.455 GHz
Antenna efficiency	75%
Antenna noise	30K
LNB noise figure	1.0 dB
LNB gain	60 dB
LNB load impedance	75 Ohms
Coupling loss (waveguides and polarisers)	0.2 dB
EIRP	44 dBw
RF/IF noise bandwidth	27 MHz
FM deviation (peak to peak)	17 MHz
Maximum video frequency	5 MHz
Pre-emphasis/De-emphasis	0.2 dB
Weighting factor	11.2 dB
Demodulator threshold	6 dB
Antenna aging, pointing & polarisation loss	0.2 dB
Signal availability (average year)	99%
CCIR rain climatic zone	F
Water vapour density	14 gm/cu. metre
Surface temperature	22 degrees C
Polarisation	Vertical
Satellite Look Angles	
Elevation angle	49.36 degrees
True azimuth angle	15.47 degrees
Azimuth compass bearing	3.22 degrees
Polarisation offset	-31.00 degrees
Modified Polar Mount Settings	
Polar axis angle	34.65 degrees
Polar elevation angle	55.35 degrees
Declination offset angle	4.87 degrees
Apex axis angle	39.52 degrees
Apex elevation angle	50.48 degrees
Clear Sky Result (no rain in downlink path)	
Path distance to satellite	37119.30 Km
Free space path loss	205.75 dB
Spreading loss	162.38 dB/sq. m
Atmospheric gaseous absorption	0.11 dB
Tropospheric scintillation fading	0.05 dB
Total atmospheric losses	0.15 dB
Effective area of antenna	1.78 dB sq. m
Antenna gain	45.15 dBi
Pre-detection noise bandwidth	74.31 dBHz
LNB noise temperature	75.09 K
System noise temperature	127.84 K
Power flux density (PFD)	-118.54 dBw/sq. m
Total carrier power	-116.95 dBw
Total system noise power	-133.22 dBw
Carrier power at LNB output	-57.15 dBw
Signal level at LNB output (75 Ohm)	
Nominal figure of merit, (G/T) nom	23.88 dB/K
Carrier to noise ratio (C/N)	16.27 dB
FM improvement (modulation gain)	19.71 dB
Signal to noise ratio (S/N)	49.18 dB
Picture quality	CCIR grade 4.8
Degraded Sky Result (99% of an average year)	
Signal availability (worst month)	97.15 percent
Attenuation due to precipitation	0.30 dB
Noise increase due to precipitation	0.54 dB
System noise temperature	144.71 K
Additional atmospheric absorption	0.02 dB
Downlink degradation (DND)	0.86 dB
Cross polar discrimination (XPD)	48.88 dB
Power flux density (PFD)	-118.86 dBw/sq. m
Total carrier power	-117.47 dBw
Total system noise power	-132.68 dBw
Carrier power at LNB output	-57.47 dBw
Signal level at LNB output (75 Ohm)	81.28 dBuV (21.28 dBmV)
Usable figure of merit (G/T) usable	23.14 dB/K
Carrier to noise ratio (C/N)	15.21 dB
FM improvement (modulation gain)	19.71 dB
Signal to noise ratio (S/N)	48.12 dB
Picture quality	CCIR grade 4.8

Earth Station Components

Basic system components

A basic satellite receiving system comprises a dish, feed horn, LNB (Low Noise Block converter), receiver, television set and VCR or the combination of video monitor and audio amplifier. For reception of worldwide video standards, a multi-standard video converter may also be necessary.

Television services designed to be received by small aperture domestic dishes are commonly called DBS or "direct broadcast services", and are confined to the K band.

The relatively large C band dishes, sometimes seen in suburban backyards, and often 3-5 metres in diameter, are called TVRO dishes (TV receive only) and are used to intercept television signals designed to be received by regional TV stations, hotels and other commercial organisations operating under copyright licensed conditions.

Typical commercial dish used in hotels

The private practice of intercepting these signals is widespread in areas of poor, or non existant terrestrial broadcasts. There are also many enthusiasts and amateur radio operators receiving such signals from around the world as a source of entertainment, somewhat similar to the practice of short wave listening.

Recently, there has been an increase in the number of foreign countries broadcasting FTA (Free To Air) to an international audience. Often these broadcasts are an extension of government funded short wave radio services. Examples of this are NHK, DW (Germany), TV5 (France), TVe1 (Spain), RAI (Italy). Such broadcasts are intended to benefit expatriate citizens and potential tourists.

Dish Types

The dish, the most obvious component of a satellite system is normally parabolic in shape and made from steel, aluminium, or fibreglass sheeting impregnated with reflective coating.

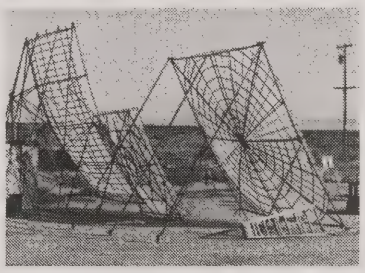
The purpose of the dish is two-fold, to collect the maximum available signal, and focus this signal into the feedhorn.

Some manufacturers use mesh or perforated sheet instead of solid sheeting to achieve some reduction in weight. The dish must also be coated with some kind of weatherproofing material to prevent corrosion and pitting of the reflective surface.

The first type of dish specifically developed for TVRO use was the "spherical" type, developed by Oliver Swan in 1978.

This antenna was suitable for fixed satellite installations with plenty of room! By placing several feedhorns at different places across the antenna, it was possible to receive more than one satellite.

By moving the feedhorn rather than the reflector, several satellites could be received. This type of antenna was first used around 1979 in outback satellite systems, utilising Intelsat 4.



Spherical antennas

Small dishes (up to 2 metres in diameter) may be produced in one piece, either spun from aluminium, hot pressed from steel, or if fibreglass, made in a mold.

There have been instances where large dishes for fixed satellite reception, have been built from other unorthodox materials.

One such unique example is the 16 metre antenna, fabricated on site in Sri Lanka using cement, and aluminium foil!

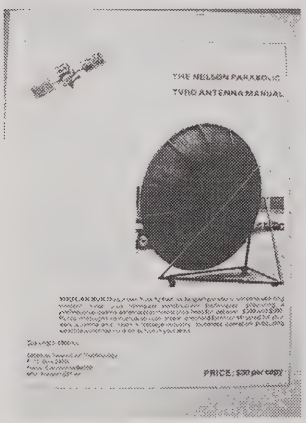
In the mid 1980's the practice of making one piece, large aperture

parabolic dishes from wood became common amongst home builders.

Concrete dish (courtesy SatFACTs magazine).

When wet, plywood becomes flexible, and provided it is supported by an accurate frame, and then coated with reflective material a useful antenna can be made at very low cost (but significant effort).

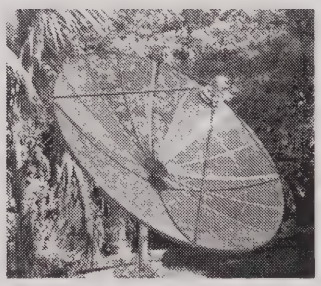
The "Nelson Parabolic Antenna Manual" is a guide to the construction of satellite dishes using this type of assembly technique.



Nelson Parabolic Antenna Manual

One piece construction is generally considered impractical for larger sized dishes which are often made up of a number of identical "petals". In addition, larger dishes have higher wind resistance, requiring stronger construction and mounting techniques than their smaller counterparts.

In practice, most domestic dishes over the diameter of 2.3m are made from aluminium expanded mesh panels, which are then bolted together to form the complete parabolic reflector. The advantages of this construction technique are lower weight, and ease of shipping.



Typical mesh dish

Despite popular myth, a mesh dish offers no less wind resistance than a solid dish, once wind velocity exceeds 10 kph. This is because the air cannot get through the holes in the mesh quick enough and forms a boundary layer following the curve of the dish.

The primary advantage of mesh dishes is that they can be assembled in-situ and that they are light. However, mesh panels are somewhat fragile, and can be damaged by hail or high winds, resulting in deviation from the true parabolic surface, and consequential gain reduction.

Large antennas for commercial installations where a reduction in performance cannot be tolerated normally use solid dishes, despite mounting and shipping difficulties.

Dish Gain

The most important parameter of the dish is its gain and this is dependant on the area and accuracy of the parabolic surface. Any imperfections or deviations exceeding 25 percent of a wave length or more from a perfectly parabolic surface can result in a significant drop in efficiency.

Size	Ku band	C band
1.6m	44dBi	34dBi
1.8m	45dBi	35dBi
2.3m	47dBi	38dBi
3.0m	49dBi	41dBi
3.7m	50dBi	42dBi

Dish size versus gain

The larger the dish, the greater the gain, provided the surface closely follows the true parabolic shape.

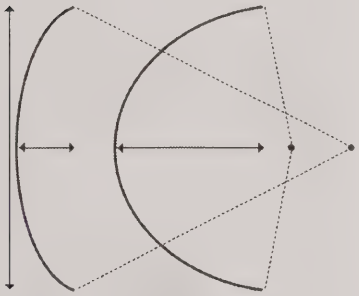
The gain of a dish is generally expressed as :

GAIN = m(D2/L)

Where D equals the diameter of the dish in metres, lambda equals the wavelength of operation in metres, and m equals the efficiency (typically 60 to 70 %). Typically, a solid dish has higher efficiency than one made from mesh panels, primarily because of the improved surface accuracy.

At Ku band, efficiency of mesh dishes can drop to

35% because of the reduced efficiency of the mesh itself and the higher surface accuracy required at Ku band (a quarter wavelength at Ku band is far shorter than that at C band).



Shallow dish (left) has shorter focal length than deep dish.

It is important to appreciate different dish designs. A parabolic dish can have either a shallow to a deep parabolic curve. This in turn will determine the focal point, which is important for correct placement of the feedhorn.

F/D ratio

Every dish has a design "focal length to diameter" or F/D ratio. This simply means that the amount of curvature built into the dish establishes a relationship between the diameter and the distance from the back of the dish to the focal point.

This ratio can easily be calculated by measuring the diameter across the front of the dish and the depth, or distance from the back of the dish to the point of intersection across the front.

In practice this can easily be done by using a piece of string stretched across the front of the dish, and a rigid tape measure. The formula for calculating the focal point is as follows.

$$\frac{F = d2}{16}$$

Where C equals the depth, D equals the diameter and F equals the focal point. One confusing aspect of this is that a dish having an F/D ratio of 0.5 is actually shallower than one having a F/D ratio of 0.25, although the magnitude of the ratio might seem to indicate otherwise.

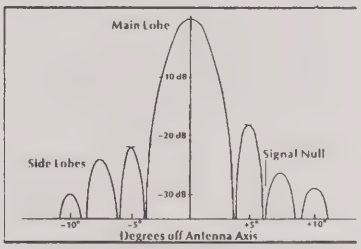
Noise Temperature

Dish noise temperature is also an important parameter, and refers to the amount of noise detected by the antenna from the surrounding environment. Factors influencing dish noise temperature include diameter, elevation and sidelobe performance.

The sidelobe performance of any dish, is most simply described as the ability of the antenna to reject signals from anything other than the intended single point source.

Sidelobe performance is also related to antenna beamwidth. If absolutely all the incoming signal was received by the main directional beam or "lobe" of the antenna, the efficiency would be very high, as all other sources of noise or signals would not be seen by the antenna.

In practice, due to reflector shape and design, some efficiency is lost due to the antenna sidelobe response. Noise is also admitted into the antenna system through sidelobe responses.



Sidelobe response chart

In general a larger dish has a lower noise temperature than a smaller dish, because of the narrower beamwidth. Also, earth noise plays a part in dish noise temperature at lower elevations.

The earth has a higher noise temperature than free space, (290 degrees Kelvin versus 5 or 6 degrees Kelvin for free space) and consequently some earth noise enters the dish via sidelobes.

For dishes "looking" at satellites having a low angle of elevation, a dish having a deep focal point, may provide a better carrier to noise ratio at the output of the LNB, as the feed system is shielded from earth noise to some degree, due to the shorter focal length.

The resultant G/T ratio, or "figure of merit" of a dish, feedhorn and LNB combination is calculated, in simple terms, by dividing the gain of the antenna, by the noise figure of the

system. That noise figure can be simplified as the sum of the dish noise temperature and the LNB. A 20 degree Kelvin (K) LNB contributes 20 degrees to the system noise figure.

Home satellite systems generally strive for a figure of merit in the 15 to 20dB/degree range, whilst commercial installations should achieve up to 30dB/degree Kelvin.

In terms of extra performance margin, a home satellite system should be built to have at least 1dB of extra C/N margin, whilst a commercial system should have an extra 3dB of inbuilt performance margin.

Offset Dishes

Offset dishes were developed primarily for use in high latitude countries, where the effect of water, snow, or ice pooling on the reflector surface degrades the performance of a prime focus dish.

Because the offset reflector is actually only a section of a larger prime focus reflector, the offset angle means that the actual angle of the reflector with respect to the horizontal plane is much higher than that of a prime focus reflector, ensuring that rain, snow and ice easily fall off the surface.

Offset dishes have very good sidelobe performance and no aperture blockage, unlike the prime focus dish.

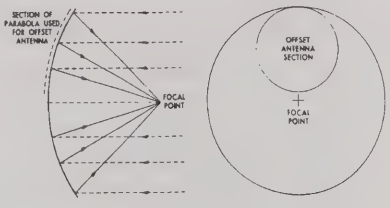
When installing such a dish, the offset angle must always be taken into account. If, for example, the calculated angle of elevation for a prime focus dish is 50 degrees, then the actual angle of elevation of an offset dish is that angle of elevation, minus the offset angle.

Most K band offset dishes used for Pay TV have an offset angle of around 26 degrees. Hence the measured angle of elevation of the reflector is 50-26 = 24 degrees.

In addition, most offset antennas are elliptical, often having a longer vertical axis than horizontal axis. This reduces the antenna beamwidth, an important parameter in countries served by many adjacent satellites.

In Australia, climatic conditions do not influence the decision to use prime focus or offset dishes, however the compact size of offset dishes has made them popular as they are easier to ship due to reduced volume.

Never the less, the prime focus dish is much easier to align and point. Figure 7 shows the relationship between prime focus and offset reflectors.



Parabolic section used for offset dish (Fig7)

Flat Antennas

A few manufacturers around the world are making flat antennas. The main advantage of a flat antenna is low profile and wind loading. This can be especially useful when a dish must be installed on a high rise building, or where architectural or planning regulations prohibit conventional parabolic dishes.

Flat antennas are also less susceptible to terrestrial interference, and have a broader alignment tolerance than their parabolic counterparts. Flat antennas can be mounted on either horizontal or vertical surfaces.

One type of flat antenna is known as a "zone plate antenna". When mounted on a vertical wall, the zone plate antenna can be skewed to point at the satellite.

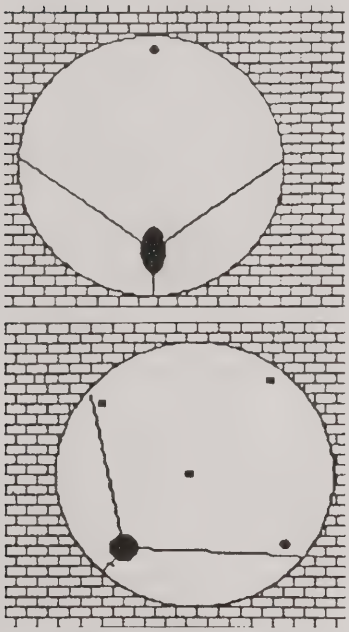
The internal construction of the zone plate antenna consists of a single piece, stepped, elliptical reflector. The base of the reflector is either moulded or machined from epoxy resin.

After machining or moulding, the reflector is sprayed with a conductive material to ensure good reflection properties at satellite frequencies. The disadvantage of the zone plate antenna, is greatly reduced efficiency when compared to a parabolic reflector.

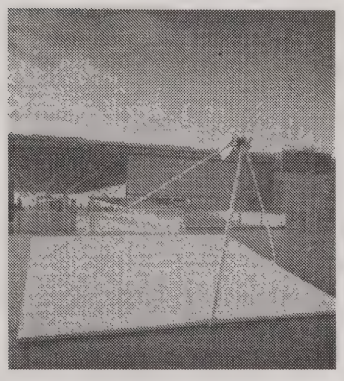
Whilst this may be of no consequence when using the antenna for K band, where larger antenna dimensions

can be tolerated, flat antennas for C band typically have an efficiency of 50-55%, requiring a much larger aperture flat antenna for equivalent performance.

Flat antenna
No skew (top)



Skewed (bottom)



C band flat antenna

Typical F/D ratio of a flat antenna is 0.7, and offset feedhorns are typically used to illuminate the elliptical reflector "potted" in weatherproof epoxy resin.

Another type of flat antenna is the "phased element" type. The typical flat plate antenna is a phased array of 256 dipole antenna elements arranged in a square, so that they are all in phase across the surface of the array. This way, the signals received by each dipole antenna are combined and fed to a waveguide.

Squarial antenna

A commercial flat plate antenna, developed in the UK for reception of BSB (British Satellite Broadcasting) is sold in the UK under the tradename "Squarial". Because the beamwidth of this type of antenna is commonly 4°-5°, they are normally wall mounted offset 45° to the vertical axis.

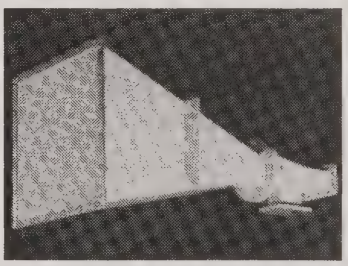
This way the sidelobes are aimed in the opposite direction to the geostationary arc. Because the gain of a flat plate antenna is uniform across the surface (unlike parabolic antennas which are normally characterised by up to 10dB "edge taper"), they are more efficient (and costly) than a parabolic dish of equivalent size.

Feedhorns

The primary function of the feedhorn is to gather the reflected energy from the dish and direct it to the LNB. At the same time, it should reject outside "noise" caused primarily by random microwave signals and background ground noise.

It is important that the feed horn illuminates the entire dish, not just part of it, to achieve maximum efficiency. Feedhorns are manufactured to suit dishes having a particular F/D ratio, so the choice of feedhorn is important.

The first type of feedhorn used for satellite television in the late 1970s was the rectangular feed type, so called because of its shape.



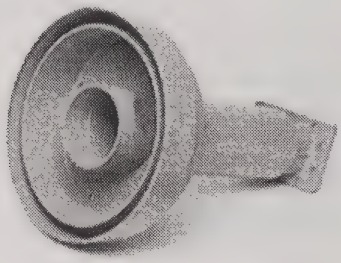
Rectangular feedhorn

More recently feedhorns have been developed to more efficiently illuminate the dish. These have all taken the form of a tubular waveguide and a set of concentric focussing rings.

There are several different feedhorn arrangements. The most simple and widely used is the "prime focus" feed where the feedhorn is placed at the focal point of the dish.

Earth Station Components

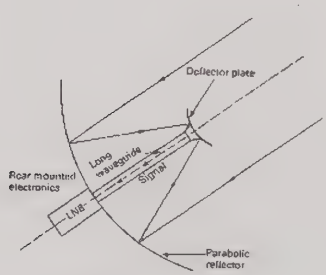
This is a simple symmetrical arrangement, and alignment is less critical because all the support components have identical dimensions.



High efficiency prime focus feedhorn

Another type of feedhorn arrangement is the "cassegrain" feed. This system uses two reflectors: the dish itself and a small sub-reflector at the focal point. This reflector has the shape of a hyperbole and reflects the signals through a hole in the centre of the dish to the feed horn and LNB.

This system has a higher gain/noise ratio and is superior in performance to the prime focus system, but only on large dishes where the dish size compensates for aperture blockage caused by the sub reflector.



Cassegrain configuration

A recent commercial offering of a sub reflector dish is the "Toroidal" dish. Capable of wide beam coverage, this multibeam antenna is built to Ku band dimensions and can be used to cover all Ku band satellites serving Australia.

Toroidal dish

Focal Point

The focal point of a dish is determined by its curve and thus the shape of the dish establishes the feed parameters as well as the focal point for the feed horn.

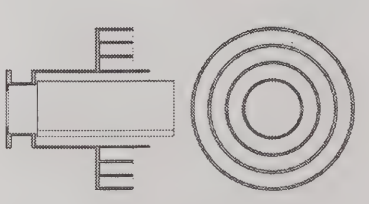
Since deep dishes have a relatively close focal point, feed horns for deep dishes must have a broad beamwidth. Shallow dishes have the focal point further away and therefore a narrower beamwidth is required. When a dish is fully illuminated its efficiency is at maximum. However, at the same time, ground noise is also at a maximum. The microwave energy from a satellite radiates in two modes, the "E" and "H", electrical and magnetic fields.

Due to the different electrical and magnetic characteristics of these two fields, a feedhorn must have special designs to allow it to "see" the dish equally in both fields. For many years the classic rectangular feed has been used in an attempt to equalise the differences between "E" and "H" fields.

An improved solution for this mismatched problem was developed in the mid 1980's through the understanding of the electrical and magnetic properties and their interaction within the feedhorn.

The solution is a "scalar" feedhorn, a circular feedhorn design, with a series of chokes or rings that equalise the two planes so that the microwave response is nearly flat from one plane to the other. In the scalar design, the "E" field tends to spill over the walls of the throat of a feedhorn to follow the outside of the feed.

A method is needed to reduce this fringing without effecting the main energy within the feedhorn. This is accomplished by using quarter wave chokes set as concentric rings around the feedhorn opening.



Scalar feedhorn

These concentric rings are a quarter wavelength in height, allowing an impedance match, ensuring the rings have maximum cancellation effect.

Once the pattern of the "E" and "H" fields is

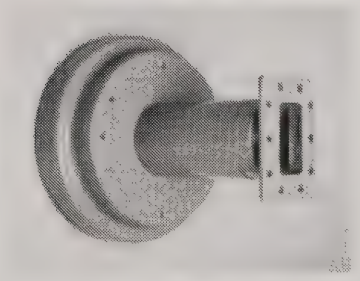
equalised, the primary function of the feedhorn is to channel the energy into the LNB.

The waveguide must have precise dimensions to keep VSWR (Voltage Standing Wave Ratio) as low as possible. Sometimes, small screws or projections extending into the waveguide at various points are installed by the manufacturer to further lower the VSWR or to correct for a shortened waveguide. High quality feed horns have a VSWR of 1.3 : 1 or lower.

Another type of feedhorn, giving superior results to the "Scalar" feed, is the "Dual Hybrid Mode" feedhorn.

The design of this kind of feedhorn comes from an adaptation of a feedhorn developed at the Jet Propulsion Laboratory for use on the Pioneer series of spacecraft. US feedhorn maker ADL was the first to combine the moded feed design with a high efficiency polariser, and to produce a feedhorn suitable for C band home satellite TV reception.

This type of feedhorn can improve the system efficiency by several dB.



Moded feedhorn

Polarisers

The feedhorn can also incorporate a polariser, a device used to select correct reception polarity. To ensure good frequency reuse, most satellite adjacent transponders are fixed alternately between vertical and horizontal polarisation.

In order to receive vertically polarised signals, the LNB/feed horn arrangement must be rotated to compensate for ionospheric cross-polarisation which may occur during the downlink.

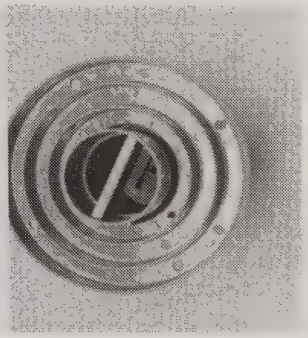
Because the LNB dipole probe is fixed when the LNB is manufactured, it cannot be moved to allow reception of different polarity signals. Nor is it convenient for the user to have to rotate the LNB every time a transponder having a different polarity is selected.

To counter these problems various mechanical rotation devices have been used over the years with varying degrees of success. The most commonly used system employs a digital proportional servo motor to rotate a probe mounted inside the waveguide.

This type of motor is sufficiently agile to change position quickly, can provide sufficient torque, and requires minimal DC current to maintain the probe position. The probe is mutually coupled to the LNB dipole antenna. This arrangement allows the remote selection of signal polarity from the satellite receiver.

Unfortunately, this type of feedhorn has significant loss, and can only be used in areas of high signal strength. Cross polarisation isolation is also poor, resulting in degraded reception, particularly in the case of digital signals.

To make things worse, the commonly used "dielectric plate" conversion system (from circular to linear polarisation) is also very lossy, and is only suitable for high signal strength areas.



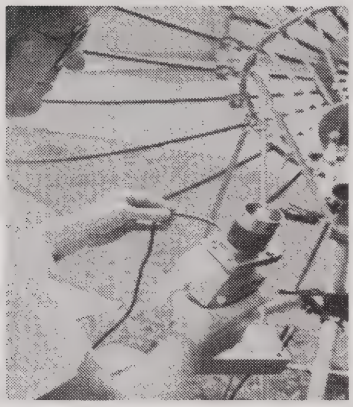
Scalar ring assembly showing dielectric plate polariser.

One "non-moving parts" solution is the magnetic polariser. This system uses Faraday rotation, where an axial magnetic field is applied to a waveguide containing ferrite material.

A current carrying coil is wound around a ferrite rod and the resulting magnetic field changes the polarisation of the incoming signal.

The amount of rotation is proportional to the amount of current flowing through the coil. The advantage of this system is the low

insertion loss, typically 0.15dB. This type of polariser is mainly used for K band reception, where the higher insertion loss of a mechanically rotated probe cannot be tolerated.



Bob Luly's C band polarizer.

In the early 1980s a C band version was displayed at the SBCA satellite show by Bob Luly, who is generally credited with the development of this type of polariser.

For C band applications, a dual polarity LNB is generally used, where the selection of vertical and horizontal signals can be controlled by the DC voltage applied from the receiver. A magnetic polariser for C band use is not commercially available, probably due to the high cost.

Most satellites use linear polarisation. Normally this means that adjacent transponders are, alternately vertical or horizontal in polarity. This is the case with Panamsat's PAS 2 and the Indonesian "Palapa" satellites.

However, other C band satellites viewable in the Pacific area utilise circular polarisation, Intelsat and the Russian "Gorizont" satellites using a combination of left hand, and right hand circular polarisation (LHCP & RHCP). In the situation where the user desires to remotely select either polarity, a mechanical polariser is used, and a dielectric plate is inserted in the throat of the feedhorn to convert linear to circular polarisation. This method introduces considerable loss into the feed system.

A far more efficient method of converting signals from circular to linear polarisation (over the introduction of a polarising element inside the waveguide) is to introduce polarising structures into the waveguide.

Fig 10 shows structures inside the waveguide that cause circular to linear polarisation conversion of satellite signals.

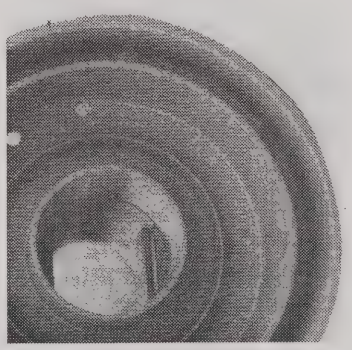
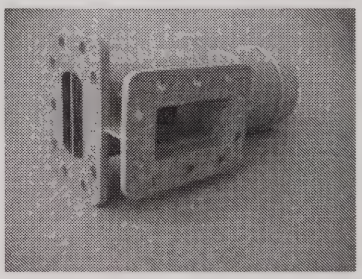


Figure 10

A further improvement involves the use of a rotating waveguide. The main advantage this system has over other types, is that it allows the entire LNB and waveguide to be rotated, to compensate for polar axis "roll", encountered when using a polar or horizon to horizon mount. This feedhorn is also manufactured in "dual band" configuration.

Ortho mode Feedhorn

This type of feedhorn is used when two signals having different polarisation need to be received simultaneously, by feeding two LNB's.



C band orthomode

This type of feedhorn is often used in SMATV installations where all available channels must operate simultaneously. When used with a suitable polarity switch, multiple receivers can be operated from the one dish, each with independent polarity control.

LNB's - Single Polarity

The LNB is a critical component of a satellite system. It is this item which largely sets the carrier to

noise ratio of the complete system.

An LNB is, in simplistic terms, a wideband mixer. The incoming satellite signal is mixed with a stable microwave oscillator to produce a 500MHz wide block of output, or IF frequencies, most commonly in the 950-1450MHz region. LNB's operating in the K band use a local oscillator frequency of 11.3GHz, whilst C band units use an LO frequency of 5.15GHz.

C band LNB

Most LNB's are produced to receive signals of a single polarisation. The waveguide "port" which is bolted directly to the feedhorn has specific dimensions.

For our part of the world, where K band ranges from 12.25GHz to 12.75GHz, the single polarisation waveguide is called WR 75. For C band, the waveguide is known as WR 225.

To calculate the IF frequency (to which the receiver must be tuned) for K band, subtract the LO frequency of 11.3GHz (11300MHz) from the incoming frequency.

For C band, the incoming frequency must be subtracted from the local oscillator frequency of 5.150GHz, to give the IF frequency to which the receiver must be tuned.

The incoming satellite signal is amplified prior to mixing with the local oscillator, and it is the noise figure of this first amplifier stage, which largely sets the LNB noise figure. The lower the noise figure of the LNB, the better the ability to receive weak signals.

As a rough rule of thumb, approximately 0.6 dB of equivalent system gain is added for every 20°K drop in LNB noise temperature.

The table below shows the relationship between noise temperature in degrees K and dB.

Kelvin	dB
010	0.148
015	0.220
020	0.291
025	0.360
030	0.429
035	0.496
040	0.563
045	0.628
050	0.693
055	0.757
060	0.819
065	0.881
070	0.942
075	1.002
080	1.061
085	1.120
090	1.177
095	1.234
100	1.291
105	1.346
110	1.401
115	1.455
120	1.508
125	1.561
130	1.631
135	1.665
140	1.716
145	1.766
150	1.816
155	1.865
160	1.913
165	1.962
170	2.009
175	2.056
180	2.103
185	2.149
190	2.239
200	2.284
205	2.328
210	2.372
215	2.415
220	2.458
225	2.501
230	2.543
235	2.584
240	2.626
245	2.666
250	2.707

Convention dictates that the noise figure of a C band LNB is expressed in degrees Kelvin, whilst that of a Ku band LNB's is expressed in dB.

LNB's having noise figures of 0.7dB (50 degrees Kelvin) are now available for K band, whilst 0.3dB (20 degrees Kelvin) is readily achieved at C band.

Enthusiasts should strive to obtain the best possible noise figure LNB. However, it is important to understand that no visible difference may be seen between a system using a 20 degree LNB and one using a 15 degree LNB.

What is important, is the improvement in performance headroom, which helps compensate for reduced satellite power due to TWT ageing, and atmospheric conditions affecting path loss.

The widespread use of digital video broadcasting has forced manufacturers to produce LNBs having far superior phase noise and gain flatness than was ever required for analogue reception. In a digital receiving system, the BER will be directly affected by the level of phase noise in the received signal. As this noise is generated by the local oscillator in the LNB, this oscillator must produce a very clean output signal, and be stable under a wide range of conditions.

One understated LNB parameter is VSWR. Although it refers to the combination of feedhorn and LNB, this parameter is very important because any mismatch between these two components will result in some of the energy of the received signal being reflected back from the LNB and hence lost. In addition any reflected signal will reduce the incoming signal, degrading the performance.

A VSWR of 3.5 to 1 will result in an increase in effective LNB noise figure of 75 degrees K !! This means that the LNB noise temperature will be 90 degrees K instead of 15 K.

Another important parameter of LNB performance is local oscillator drift. For analogue satellite work, LNB LO drift of +/- 2.5MHz or so is acceptable, as the video transponder bandwidth is typically either 18 or 30MHz, and the receiver AFC can track LNB drift.

Digital MPEG receivers require a higher degree of stability, less than 800KHz total drift is preferred.

For NBFM (narrow band FM) SCPC radio reception, the channel bandwidth is only 30 kilohertz.

Such an amount of drift would prevent repeatable reception on a day to day basis, as the LNB LO frequency shifts with the change in ambient temperature, and hence the IF frequency would have also moved to compensate.

This problem has been overcome using a PLL LNB.

Phase locked loop LNB

This type of LNB can be specified with local oscillator stability of +/- 10KHz to +/-500KHz depending upon the application, quite a dramatic improvement over the standard DRO type.

Wideband LNBs

There is also an increasing number or manufacturers producing wideband or "Universal" LNBs. For K band this means covering from 10.5GHz to 12.75GHz. Normally two local oscillators are used, one at 9.75GHz and the other at 10.6GHz. Switching between local oscillators is achieved through the 22KHz or DiSEqC switching facility, common on almost all modern satellite receivers.

Even though our part of the world is classified as ITU region 3, and has been allocated 12.25-12.75GHz as the downlink frequency range for DBS services, we can still view satellite signals outside this allocation. One such service is Le Bouquet Francais (LBF) operating on 11.610 GHz on Intelsat 701 (180E).

Wideband coverage of C band is presently limited to Apstar, Thaicom and the Palapa C series satellites, which offer extended C band coverage from 3.4GHz to 4.2GHz. LNBs intended for use over this extended band must be specially produced, so that the frequency response rolls off below 3.4GHz.

Integrated LNB and Feedhorn

Further developments in both C and K band feedhorn efficiency have been made

by integrating the LNB, feedhorn and polariser in the one package, called the dual polarity LNBF.

This is done by fitting the LNB with two RF stages, each with a separate dipole probe, one dedicated to horizontal polarity reception, the other dedicated to vertical signal reception.

These probes are switched by changing the DC bias on the coaxial feed line. This arrangement eliminates the 0.2dB or so insertion loss of the magnetic polariser, improving the BER.

LNB Variations

Promoted as being a "one cable solution" the latest C band dual polarity LNB allows simultaneous reception of horizontal and vertically polarised signals, down the one IF cable.

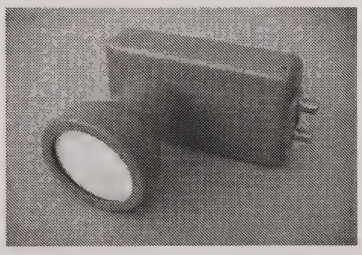
One cable solution LNBF

This type of LNB converts all incoming vertically polarised signals to an IF block of frequencies from 950-1450 MHz, and simultaneously all horizontally polarised satellite signals are converted to another block of IF frequencies from 1500 to 2000 MHz.

As long as the receiver used is rated to 2000 MHz, and provided the IF cable is also so rated, a simple IF splitter is all that is needed to separate vertical and horizontal signals at the receiver end of the cable.

This special type of LNB has two internal local oscillators, one running at 5.15 GHz, the other at 5.7 GHz. In practice, there is some performance / convenience tradeoff. The performance of the "one cable solution" is slightly below that of a standard dual polarity LNBF, and this may be an important factor when trying to receive a weak signal.

Because it is impossible to eliminate mixing products from the output, the one cable solution approach has never been used for our region 3 ITU Ku band. To circumvent this problem, several makers produce the dual polarity twin output version in Ku band.



Twin output dual polarity Ku band LNBF

This allows connection of two receivers, each having independent polarity control.

In Australia, where Pay TV and the Optus "Aurora" services now operate on opposite polarities on the same satellite (Optus C1) this is a very useful device.

Dish Mounts

Regardless of the type of dish used for satellite reception, there are a number of different mechanical mounts that can be used to attach the reflector to the ground.

Ground Mount

The simplest type of mount is the ground mount, which is designed for fixed, single satellite reception. This mount comprises a triangular base frame, which sits horizontally on the ground (or any other flat surface). The reflector is fitted with a rim assembly, which has two pivot points at the front edge of the reflector rim, which form a support hinge with the base frame.

Typical ground mount

A telescopic elevation arm, made from two sections of concentric pipe, forms the third support

point, from the rear of the base frame to the reflector rim.

This elevation arm is fitted with a friction screw, allowing the length of the arm to be set, corresponding to any value of elevation.

The base frame can be fixed to a horizontal concrete base using steel stirrups and dynabolts.

Where permanent fixing is not permitted, the mount can be secured by ballast, comprising multiple pre-cast concrete slabs. In a temporary situation, drums of water can also be used.

Az/El mount

This mount is designed to allow the dish to be mounted on a vertical post or pole. Elevation can be varied, normally by adjusting the effective length of a piece of threaded steel rod.

Azimuth adjustment is made by simply rotating the mount on the pole. For Az/El mounted dishes, the supporting pole is normally cemented into the ground.

A good general rule of thumb is to bury as much of the pole below the ground as that length above the ground. The length of pole above the ground should be 100mm or so more than half the diameter of the dish.

This way, when the dish is tilted down to an elevation of zero degrees, the lower rim will not touch the ground. eg for a 3m dish, the pole length above the ground should be 1.5m plus 100mm = 1.6m.

El/Az mount

A recent development is the motorised El/Az mount. This involves fixing the dish to a pole mounted on a bearing, which allows desired changes in azimuth to be made using a standard actuator.

The advantage of this configuration is that no feedhorn correction for the polar axis changes is required as the dish azimuth is changed, as the dish moves in a straight line, rather than following the geostationary arc.

However, an additional actuator is required for elevation adjustment, as no declination adjustment is available.

Polar mount

A polar mount enables an antenna to track the geostationary arc using a single motor to drive the dish in the azimuth axis.

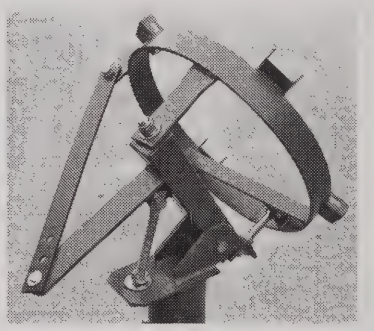
The most critical adjustment of any polar mount is the angle of declination. This is the adjustment that prevents the dish from looking into deep space, by lowering the angle of the reflector elevation, so that is "sees" the geostationary arc.

The angle of declination required is determined by the site latitude, and this value is usually supplied by the hardware vendor.

The angle of elevation of a polar mount varies with changes in dish azimuth. As the azimuth changes, the dish "rolls" around the axis of the mount, changing the angle of elevation.

As the limits of observation are +/- 81.3 degrees from the dish longitude, a polar mount should be designed to operate within the appropriate azimuth range.

For the dish to track the geostationary arc correctly, it is necessary to make a few simple, but very accurate adjustments. The mount must be aligned so that the point of highest elevation occurs at true north.



Polar mount

The angle of elevation for the site must be set, and the declination must be also be set to a pre -calculated value determined by the site latitude. The degree of accuracy must be high, and it is generally necessary to use a digital inclinometer capable of 0.1 degree accuracy.

Horizon to Horizon mounts

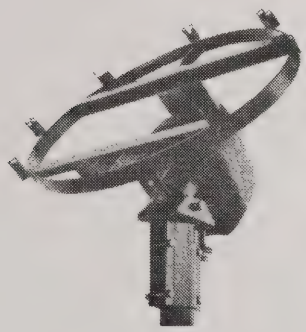
Horizon to Horizon (H-H) mounts are used when a dish must be driven significantly past the centre of gravity. In Australia, such

a mount would be used when a TVRO system is required to receive satellites on both the western horizon, and also the eastern horizon.

In Western Australia, it is possible to receive satellites from 60 to 180 degrees east longitude. Even along the east coast, satellites can be viewed from 75 to 180 degrees east longitude.

If reliable dish control is required across this azimuth range, a H-H mount must be used.

A H-H mount comprises a 36 volt reversible DC motor and a reduction gearbox, directly driving a series of toothed gears, or in some models a dual chain drive. These gears are immensely strong, and due to the reduction gearbox, the drive train is capable of very high torque. In addition, most H-H mounts use five reed sensors for more accurate positioning, compared to the single reed used on actuators.



Horizon to Horizon mount

For reception of satellites in inclined orbits a second actuator, used to control dish elevation variations above and below the "nominal" elevation of a satellite in the geostationary arc, must be used. This applies equally to polar and horizon to horizon mounts.

A heavy duty actuator should always be used for this purpose. Whilst the amount of travel required may only be a matter of 10 cm or so, the load bearing capability of the actuator is most important.

Dishes used to receive inclined orbit satellites must also be well balanced, often requiring the addition of a counter-weight.

Dish Accessories- Actuators

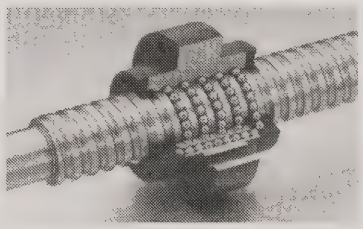
An actuator, or "linear actuator" as they are sometimes called, is a motorised drive unit, designed to move the dish in one axis. Mechanically, a 36 volt reversible DC motor is driven through a reduction gearbox, to drive a screw which either extends or retracts a telescoping tube located inside a fixed external tube.

There are two mounting points on an actuator; an adjustable collar which can be slid to any position on the external tube, and a swivel eye, located at the end of the internal tube.

This style of actuator is called and "acme screw" type. Actuators are available in standard sizes: 6, 8, 12, 18, 24, 36 and 54 inches. The length of the extension available, is generally one inch less than the nominal size.

A superior type with far less internal friction loading is called a "ball screw" type. Due to the additional cost of this type of unit, it is seldom used in domestic installations.

In addition to the DC motor and gearbox, all actuators have some kind of feedback mechanism, to allow remote control.



Ball Screw

Most actuators used today utilise a rotating magnet and reed switch as the feedback elements. For every rotation of the magnet, the reed switch operates. When fed with a 5 volt supply, the output of the reed switch appears as a series of 5 volt pulses. These pulses can be counted and memorised by the appropriate remote control drive unit.

Past actuator designs have used potentiometer or optical sensors. These two feedback methods are now considered obsolete. Care should be taken to select actuators using a sensor system compatible with available dish controllers.

In addition to controller software limits which prevent an actuator from being driven too far (into a tree or the garage!!), most

modern actuators have inbuilt limit switches.

These switches comprise a micro switch, through which the DC voltage to the motor flows. The micro switch is operated by an adjustable cam, driven by the motor gearbox, which ensures the switch operates (interrupting the DC voltage), when a mechanical limit is approached.

A reverse polarity diode ensures the motor can always be driven in the opposite direction, away from the limit.

Figs. 20a and 20b show both electrical and mechanical layout of a typical actuator.

The micro switch cam can be adjusted to provide any desired limit. Normally there are two micro switches, one each to set the minimum and maximum actuator travel. The minimum travel switch is normally set at the factory. It is important that limit switches are set prior to commissioning of the satellite system.

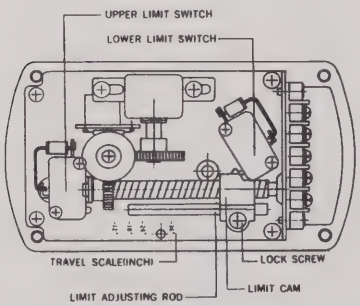


Figure 20a

The limiting factor of dish actuators is the amount of available travel. Once a dish is driven by an actuator past the centre of gravity, an enormous amount of torque is required to move the dish.

Actuators do not have this capability, and the use of an actuator in this kind of situation, normally results in a bent outer tube.

This is why suppliers recommend fitting the actuator to the same side of the dish as the majority of satellites are located. This means that is most satellites are located west of the dish site, the actuator should be installed on the western side of the dish.

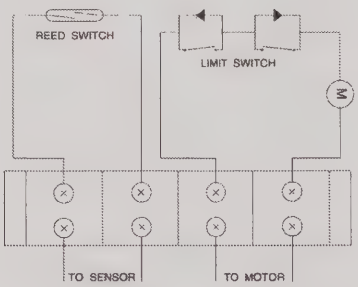


Figure 20b

The appropriate mechanism for moving a dish through a large azimuth range, is, as the name suggests the "horizon to horizon" drive.

Recently, in an attempt to reduce actuator noise, several manufacturers have introduced a gearbox utilising nylon gears. A further development incorporates a drive system utilising a toothed drive belt instead of direct gears, between motor and gearbox.

The results of this development are quite astonishing, and the use of this type of actuator, particularly when used in conjunction with a solid dish, can result in far lower actuator noise levels than has previously been possible.

Actuator Controllers

All actuators must be driven by a controller, which in simple terms is a 36V DC power supply with polarity reversal capability and a microprocessor controlled counter with memory. The controller has the ability to drive an actuator motor whilst counting feedback pulses from the actuator reed and rotating magnet assembly.

Single axis Controller

By storing the number of pulses in memory, a controller can be used to drive a dish motor to a memorised position corresponding to the correct azimuth for a satellite location. All modern positioners utilise infra-red remote control.

Since the advent of DiSEqC switching, a dish controller deriving the memorised dish position from a digital receiver has become popular.

The commercial realisation of this design is marketed under the name "V-Box".

The primary advantage of this system is the elimination of one remote

control unit, as the positioner takes actuator pulse information from the digital receiver itself, transferring this information as part of the DiSEqC switching stream.

There is a simple coaxial connection between the receiver and V-Box and digital receiver, and the usual motor and reed connections between the V-Box and actuator.

As far as the user is concerned, the operation of moving the dish between satellites becomes transparent. The user simply selects the desired channel, the receiver recalls the information form internal memory and instructs the V-Box to drive the actuator to a given pulse count.

Robot Positioner

A recent development in antenna positioners is the "Robot Positioner", made in Japan.

This system comprises two items: the indoor control unit, and the dual axis positioner module, mounted between parabolic reflector and mounting post. The interconnecting cable uses 18 conductors, which carry motor voltage and sensor feedback voltages.

A sophisticated microprocessor controller ensures azimuth accuracy of 0.01 degrees per pulse, and elevation accuracy of 0.0025 degrees per pulse, ensuring very accurate dish pointing.

The microprocessor calculates the azimuth and elevation of every available satellite, based on the latitude and longitude of the dish site.

The system also has an "auto" fine tune feature, where the satellite signal is peaked using AGC voltage from the satellite receiver, if the satellite does not appear in the predicted position i.e. an inclined orbit satellite.

Whilst relatively expensive, this device does offer automatic dual axis positioning.

Robot positioner

Unfortunately, the strength of the Robot gearbox limits the maximum dish size, with which it can be used to 3m. The unit is also not suitable for high wind areas. Nevertheless, it is anticipated future developments of the product will eliminate these shortcomings.

Actuator Cables

Both actuators and horizon to horizon mounts require suitable cabling to ensure reliable operation.

Each motor requires 36V DC, and each sensor requires two conductors to carry feedback pulses to the dish controller. Conductors carrying the 36V DC need to be rated at 6 to 7.5 amps, to ensure minimum voltage drop over the entire length of the cable. A standard length is 25 metres, although any length, provided the internal resistance of the cable is low, can be used.

Conductors having a cross sectional area equivalent to 240V power cable can be used. In fact commonly marketed "3 phase flex" contains 4 appropriately rated multistrand conductors, and is perfectly suitable.

Similarly, although having less current carrying capability, automotive trailer cable is also suitable.

The conductors used for the feedback sensor are only required to carry 5 volts at a few milliamps, and so can be of lighter gauge. Ideally the sensor cable should also be shielded, to prevent miscounting. If shielded cable is used, the shield should be left disconnected at the controller end, and grounded to the dish at the far end.

In the event that shielded cable is not available, standard telephone twisted pair, or "Cat 5" can be used.

Care should be taken when using this kind of cable, as the conductors are solid, not multistrand, and can easily fatigue and fracture during normal use, through flexing. The cable should always be run in

flexible conduit for protection.

Coaxial Cables

The choice of cable used to connect LNB and receiver is vitally important. The cable must be capable of carrying the down converted, 500MHz block of frequencies, between 950 and 1450MHz. In the case of a One Cable Solution or dual band mixer, this can extend to 2050MHz.

In addition, use of extended C band frequencies (3.4-4.2GHz) has pushed the IF upper frequency limit to 2300MHz, so attenuation is also very important. The following table shows attenuation figures for various types of 75 ohm cable.

Atten	59	6/U	11/U
500	18	14	9
1000	26	20	13
2000	42	32	22

Attenuation table (per 100m)

Convention dictates that the cable impedance for satellite TV (and TV work in general) is 75 ohms. 50 ohm cable is used for RF communications applications.

The most important parameter, more important than attenuation is shielding.

Most modern cities are becoming saturated with GSM mobile, trunked radio, and other RF sources. These are all potential sources of interference to a domestic satellite TV system. For this reason it is important to the use the best available cable for satellite systems.

For short cable runs, up to 50 metres, RG-6/U cable is recommended. This type of coaxial cable has reasonable attenuation figures, and is compatible with "F" connectors commonly used on hardware (LNBs and receivers).

Quad shielded RG-6/U provides superior immunity to adjacent RF energy, and has replaced the dual shielded type, more commonly used in the past.

This cable is often silicon flooded to ensure moisture cannot penetrate either between jacket and braid, and has two layers or aluminium foil sandwiched between two layers of tinned copper braid.

The solid centre conductor of RG-6/U cable is copper clad steel. This ensures the centre conductor is strong enough to penetrate the gap between the spring loaded contacts in a type F socket.

RG-6/U cable is therefore not as flexible as RG 59, another 75 ohm cable of similar physical dimensions, but not suitable for TVRO applications.

Experience dictates that only RG-6/U cable with foam dielectric is suitable for TVRO installations.

Cable having a "honeycomb" air dielectric may have slightly lower loss, but the risk of moisture entry and retention in the honeycomb structure far outweigh this factor.

Once moisture enters a coaxial cable, it can be drawn by capillary action for many metres, causing the braid to corrode, and eventually break down.

The coaxial cable in a TVRO system always has some DC voltage between the centre conductor and the braid (this voltage feeds the LNB).

Any moisture between these two conductors will cause electrolysis, finally resulting in signal loss.

For longer cable runs, heavy duty cable, called quad shielded RG-11 should be used. This cable has a larger diameter than RG-6/U, and the correct connectors must be used. Because this cable has a larger outside diameter, it is not as flexible as RG-6/U.

Hence it is normal to use short RG-6/U "tails" to connect to the LNB and receiver i.e. at each end of the cable.

Due to the higher cost of RG-11, it is normally only used in commercial installations.

Regardless of the cable used, it is important to use large radial bends, and avoid kinks and other distortion of the cable during installation.

The introduction of digital transmissions means that much more attention now needs to be paid to ensuring that the impedance of the cable is not compromised by crushing or compressing the cable.

This kind of damage can cause an increase in the

received bit error rate, and introduce errors into the video and audio produced by a satellite receiver.

It is preferable to run coaxial cable in conduit to ensure adequate protection.

Connectors

Most of the IF signal connectors used in a TVRO system are known as type "F". Virtually all LNB's and receivers are fitted with type F sockets.

Despite their cheap appearance, the 75 ohm male type "F" plug, designed to be fitted to RG-6/U coaxial cable, has quite good performance, in terms of impedance matching and insertion loss.

This is because the connector uses the metal casing of the connector as a continuation of the coax shielding, whilst utilising the coaxial cable itself as the connector dielectric and centre conductor.

The simple screw on F type plug is easy to fit, requires no special tools, and has good performance.

There are different versions of this plug manufactured for RG-59 and RG-6 coax cable, so care must be taken to ensure the correct type is purchased.

Screw on F plug

There are special F type plugs for the larger diameter RG-11 coaxial cable.

To successfully fit these connectors, either a special crimping tool, or a soldering iron is needed, depending upon the type.

There are a number of F series adaptors in use today, including the F81 coupler (female-female), and the F female to BNC male, used on many measuring instruments.

Weatherproofing

Where an F type connector is used externally, it is very important to take steps to ensure that moisture cannot enter the connection. There are two methods commonly used to ensure the ingress of moisture does not occur.

Self amalgamating tape is a rubber based self adhesive tape, similar in appearance to electrical insulation tape.

What makes this tape so useful is the amalgamating properties between successive layers. By winding several layers of the tape around both the male and female components of the termination, the tape forms an adhesive bond to both the connectors and to itself, forming a waterproof barrier.

Self amalgamating tape, after application has a life of many years, can be removed (with some difficulty) but cannot be re-used). If component inspection or replacement is required, the tape can best be removed by slitting the covering with a sharp knife.

Another effective method of weatherproofing an F type plug connection, is to use a rubber boot. This is particularly effective where there is some likelihood that the cable join may require inspection at a later time.

An automotive spark plug cover forms a perfectly waterproof seal over RG-6/U coaxial cable, and is pliable enough to enable it to be slid over an in line F type plug.

Where two lengths of cable are to be joined together, it is necessary to use a cable coupler (female to female) and two rubber boots. Pushing the rubber boots together forms a weatherproof seal.

2 rubber boots covering cable joiner

If the joint is to be left in the open, exposed to rain, it is also necessary to seal the junction of the two boots, with a layer of self amalgamating tape.

In addition, the use of a rubber boot to waterproof an LNB output socket also serves to offer cable support at the plug entry point.

LNB Covers

In addition to the use of self amalgamating tape and rubber boots, it is also a wise idea to use an LNB cover. This effectively gives

protection to the LNB, feedhorn and their electrical connections.

The size of LNB covers varies, depending upon the size of the LNB and feedhorn. There are two basic sizes, one each for C and K bands.

Most large aperture dishes (2.3m and larger) are supplied with an LNB cover which is large enough to cover not only the LNB, but also the complete feedhorn assembly. This is a great advantage when using a dual band feedhorn, where multiple coaxial connections are made to the LNBs. Quick and easy removal of the cover makes maintenance a simple task.

This type of cover comprises two parts, the "nose cone" and the mounting ring.

The mounting ring is secured by the feed arm bolts, and fits between the feed arm flanges and the scalar ring of the feedhorn.

Most larger dishes use 4 feed arms, so the mounting ring is thus held by four bolts. The "nose cone" is secured to the mounting ring by 4 plastic clips, spaced at equal distances around the perimeter of the mounting ring.

When a feedhorn cover is not available, a bucket can be used to cover a C band feedhorn, and a plastic soft drink bottle (after removal of the neck with a sharp knife), can be used to protect Ku band feedhorns. Covers made from UV stabilised plastics will last even longer.

Cable ties can be used to secure such homemade covers. Generally clear or white cable ties are not UV stabilised. However black cable ties are quite suitable.

Black LNB cover can be painted silver to reflect sunlight

Although normally black in colour to match the dish, repainting the feedhorn cover white, silver or some other light colour will keep the LNB up to 40°C cooler than if it were exposed to direct sunlight.

Line Amplifiers

Line amplifiers are used to overcome coaxial cable losses. Line amplifiers are normally powered up the coaxial cable by the receiver, and hence could be fitted anywhere in a long cable run.

Line amplifier

A common misconception is that the installation of a line amplifier will improve the reception of a satellite signal. This is untrue.

The carrier to noise figure of any TVRO system is set by the performance of the dish, LNB and feedhorn.

All a line amplifier does is further amplify the output of the LNB, to overcome cable losses. It cannot improve the C/N ratio, or picture quality.

Most receivers will accept an input signal level from -30 to -60dBm. It is important to present the correct signal level to the satellite receiver for optimum results.

Feeding an analogue receiver with more than -30dBm and the video produced will appear "grainy". Feeding the same receiver with less signal than -60dBm, and the picture will become noisy.

Most LNB's produce an output level of around 0dBm. So it can be seen that, even if 30dB of level were lost in the coaxial cable, there would still be sufficient signal level at the receiver.

The worst case attenuation of RG-6/U coaxial cable (at 2000MHz), is about 45dB per 100 metres. Even in this case, no line amplifier would be needed, if the coaxial cable runs directly from LNB to receiver.

However, every time an IF splitter is used (to feed another receiver), attenuation is added to the system. A two port splitter introduces 4.5dB of attenuation and a 4 port splitter increases this to 6dB, so it can be seen that,

in some circumstances, where a long cable run and multiple splitters are used, a line amplifier might be necessary.

Also, if the satellite receiver is insensitive, some extra drive might be needed.

Line amplifiers having a nominal 15dB to 18dB of gain are available. These amplifiers are "tilt compensated", meaning that the gain is matched to the attenuation characteristics of RG-6/U cable.

At lower frequencies where the cable has less loss, the amplifier has less gain. At higher frequencies where the cable has higher attenuation, the line amplifier has higher gain. The ideal result is a flat frequency response across the entire operating frequency range.

Where a line amplifier is used, it should be placed halfway down the coaxial cable run , where it can do the most good.

It is important not to fit the line amplifier too close to the LNB, where it could be overdriven into compression.

Line amplifiers also add noise to a receiving system. The noise figure of a typical line amplifier is at least 6 dB. As there is no advantage in adding noise to a system, line amplifiers should only be used to overcome cable loss.

Splitters

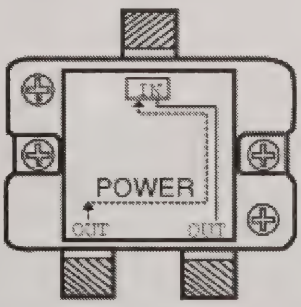
A splitter is a device that can be inserted in the coaxial line between receiver and LNB, to allow the connection of multiple receivers to the one dish. Splitters are available configured from 2 to 8 outputs, for domestic use.

Normally one "port" of the splitter allows DC voltage to pass, ensuring that the LNB is always powered. The other ports can then be connected to as many receivers as desired.

Another type of splitter uses PIN diode switching to switch the output port fed with the highest DC voltage to the LNB. This type is often called an "intelligent" splitter. All ports will be marked as "power passing".

Because a splitter must operate at frequencies up to 2300MHz, the internal circuitry uses minute components, and is housed in a metal, weatherproof enclosure.

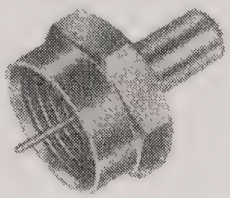
There are dedicated spitters available for TV signal distribution. This type of splitter looks similar in appearance but has an upper frequency limit of around 900MHz, and has no power passing capability. Hence they are unsuitable for satellite TV work.



Satellite splitters show DC path

Terminators

A terminator is a coaxial 75 ohm resistor, used to terminate unused ports on a splitter. This is necessary to ensure that signal reflections, which would degrade performance, do not occur, and to ensure system impedance is maintained. This is very important in digital systems where signal reflections at the receiver input must be minimised.



75 ohm terminator

Terminators must not be used on splitter ports carrying DC voltage. Not only will the 75 ohm terminating resistor be destroyed, it is likely the satellite receiver supplying the voltage will also be damaged.

Polarity Switches

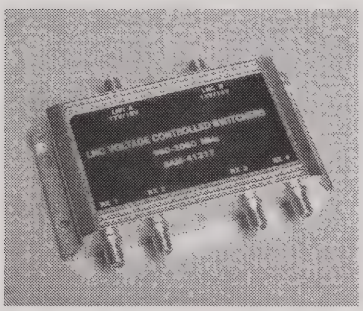
There are two types of commonly used polarity switch. One type, commonly called the multiswitch, allows the connection of two LNB's which when used with an ortho mode feedhorn, allow the same dish to receive signals of opposite polarisation simultaneously.

This type of switch allows connection of multiple receivers, and utilises the 14/18 volt DC switching capability of modern receivers to switch

between the two LNB input signals.

This way, multiple receivers can be connected to one dish, each receiver retaining polarity control.

The diecast metal construction ensures good immunity to external RF fields.



Multiswitch

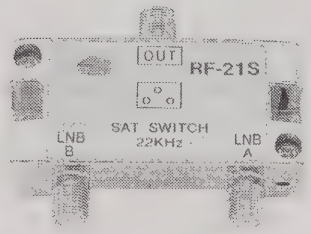
22KHz Switches

One common method employed to connect two RF outputs to a single receiver input is to use a "22KHz switch".

This type of switch will only operate with satellite receivers capable of generating a 22KHz pulse stream. The pulse stream is superimposed on the DC voltage feeding the LNB, and does not affect reception performance.

The external switch is housed in a weatherproof enclosure, and has an inbuilt 22KHz detector which switches input ports when it detects the pulse stream.

This way, either of two inputs can be selected by pre-programming the 22KHz tone to be either on or off, depending upon which input source is desired.



22KHz switch

As most modern satellite receivers already have two input ports as a standard feature, or at least also have 0/12V switching capability, the additional 22KHz switching facility allows expansion for up to 4 inputs.

DiSEqC switches

A further enhancement of the 22KHz switch is the DiSEqC switch. DiSEqC is an open standard that stands for Digital Satellite Equipment Control, which was developed after consultation between EUTELSAT (the European Telecommunications Satellite Organization) and the European satellite industry during the late 1990's

Since that time there have been two versions of the basic DiSEqC specification: Version 1.0 (one way) and Version 2.0 (two way).

The DiSEqC system can be integrated into consumer satellite installations to replace conventional analogue (voltage, pulse or tone) switching and all other control wiring. It can also co-exist with these earlier switching systems.

To understand the advantages of DiSEqC, we must first understand the necessity for its creation and the systems it replaces.

Since the earliest satellite, demand for channel capability has increased.

Initially, satellites operated only one signal polarity, progressing to multiple polarities by 1985.

In order to squeeze more channels into a given bandwidth, channels are transmitted with either vertical or horizontal polarization.

The conventional LNB responds to the DC supply voltage to change polarization, by convention 13V for vertically polarised signals and 18V for horizontally polarized signals. In populated areas of the world satellites are co-located, sometimes as many as 8 satellites at one location, each operating on a different band. So the standard LNB has a problem to switch between polarities and also frequency bands.

This problem was overcome with the introduction of the "Universal" LNB.

The Universal LNB switches polarization with voltage, and frequency bands with a 22KHz tone.

The LNB is designed to switch local oscillators when it receives the tone. So most receivers incorporate a 22KHz tone generator, which (apart for the Universal LNB application) can be used to operate

Dish Accessories

22KHz switches feeding signals from one of a pair of LNB's to the receiver.

DiSEqC is an extension of this idea, relying on a switchbox that detects the 22KHz tone pulsing on and off. DiSEqC "messages" are sent as a sequence of short (500uS) bursts of 22KHz tone, modulated onto the LNB voltage carried by the coaxial cable from receiver to LNB.

The DiSEqC hardware requires a "master" and "slave" IC which form the communications bus in its simplest implementation. The master resides in the satellite receiver, and the slave resides in the LNB or DiSEqC switch. It is intended that multiple levels of DiSEqC control be available by cascading "slaves" using a loop through system.

In summary the main advantages of DiSEqC are standardized digital system with non proprietary commands, switching in multi-satellite installations, backwards compatible with 13/18 volt and 22KHz tone switching, elimination of switching problems caused by incompatible system components and easier receiver installation using device recognition via optional two way communication.

Dual Band combiner

A result of the introduction of the "one cable solution" LNB, is the dual band combiner.

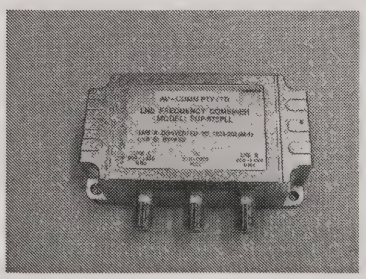
The name relates to the function of combining two IF output bands onto one cable output.

The device is housed in a small metal enclosure and contains a two port splitter, a 600MHz oscillator, a mixer, and an output amplifier.

Input 1 (the "bypass" port) allows the output signal from an LNB to pass through the combiner without change. Input 2 (the "convert" port) routes the signal to the mixer and 600MHz oscillator, producing a second output band, 600MHz removed from the input.

The output spectrum hence contains one 500MHz wide block of frequencies from 950-1450MHz, and a second 500MHz wide block from 1500-2000MHz. In this way, two signals can be combined down one cable, a simple solution compared to running a second cable.

The dual band combiner can be used to combine any combination of C and K band signals. All that is required for distribution of the signal is a splitter rated to 2000MHz and a receiver capable of allowing the user to reprogram the LNB local oscillator.

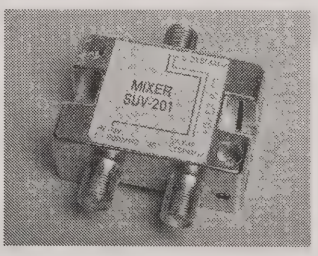


To combine two K band signals, receiver LNB local oscillator values of 11300 and 10700MHz can be used. To combine two C band signals use local oscillator values to 5150 and 5750MHz.
Similarly, to combine C and K band, local oscillator values of 5150 and 10700MHz or 5750 and 11300MHz should be used.

Satellite/TV combiner

Another handy device is the SAT/TV combiner, which can be used (provided the coaxial cable is appropriately rated) to combine both satellite IF and terrestrial TV signals down the one cable. Two such devices are required for each site, one acts as a combiner at the roof end of the installation, the other acts as a frequency selective splitter at the receiver end of the cable.

This eliminates the necessity of having to run a dedicated satellite cable, where there is an existing RG6 or higher rated terrestrial TV cable in place.



Satellite/TV combiner

Receivers-analogue

Even though digital receivers have become the "norm" since the late

1990's, there are still analogue services operating on a few satellites.

For economic reasons, analogue broadcasts will persist in some markets. Hence this explanation of analogue satellite receivers.

Initial frequency conversion from either 4GHz or 12GHz to the first IF (950-1450MHz) is done in the LNB (Low Noise Block converter) which is essentially a low noise amplifier and frequency converter in one package.

This converter produces a block of output frequencies 500MHz wide, which is then fed via coax cable to the receiver.

The receiver contains the second frequency converter, and a local oscillator which is either manually tuned or stepped using a synthesised PLL (phase locked loop) circuit. This provides a second IF often at 479.5MHz, which is then amplified, filtered and detected using a balanced demodulator to provide a baseband output.

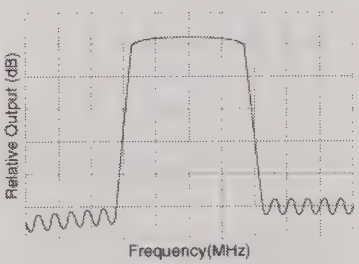
In a modern receiver, most of this signal conversion takes place in the tuner module. This baseband output contains all the video and sound sub carrier information. After further filtering to remove certain video components from the audio sub carriers, the video is processed using the standard video detector.

The audio is demodulated using either a PLL capable of covering 5-8MHz or a quadrature detector operating at 10.7MHz. This second approach allows the use of standard wide band FM filters but does not allow any flexibility when detecting either very wide or very narrow audio sub carriers.

To maximise satellite use, a number of transponders or satellite channels are allocated within the downlink pass band. These may be either full or half transponders having a band width (in many cases) of either 36MHz or 18MHz respectively.

Because the signals are FM, every effort should be made to obtain a signal level that is sufficient to take the receiver into limiting, i.e. above threshold.
This means making the receiving system as efficient as possible.

One part of the receiver that plays an important role is the IF filter. In modern receivers, this is an integral part of the tuner module.



Typical frequency response of a SAW filter

The type of filter used is called a SAW (surface acoustic wave) filter, and is characterised by very steep skirts. The bandwidth of such a SAW filter is quite important. Obviously, if the bandwidth of the filter is 36MHz and the band width of the signal being received is 18MHz, a considerable amount of noise will also pass through the filter, degrading the signal to noise ratio (S/N ratio) of the receiver. If a receiver with a bandwidth of 18MHz is used instead then there will be an improvement of 3dB in the S/N ratio. In practical terms, a half transponder signal can be received using an IF filter having a bandwidth as narrow as 10-12MHz.

The trade-off is less intense colour, slightly noisy audio and often tearing of superimposed lettering, and black or white sparkles in saturated colours, especially bright blue and red.
These effects occur when the FM carrier from the satellite is modulated heavily enough to move the instantaneous frequency outside the pass band of the IF filter.

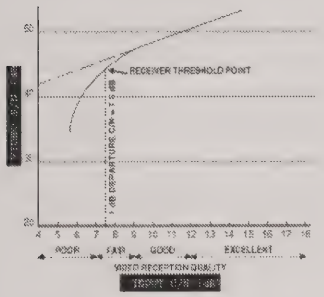
As might be expected, the video signals that fall into this category are those which contain brightly saturated colours and sharp contrast divisions.

The lower colour saturation, accompanied by lower modulation levels and overall "softening" effect of film reproduction means that movies are the least prone to this type of distortion.

Dish Accessories

Every receiver has a threshold point expressed in dB C/N.

As the C/N falls below threshold the video output becomes increasingly noisy.



C/N V's S/N

The threshold of the receiver is defined as the point at which the relationship between the Carrier to Noise ratio (C/N) of the incoming signal and the signal to noise ratio (S/N) of the resulting video becomes non-linear.

Above the threshold point, each 1dB increase in C/N will cause a corresponding 1% increase in S/N of the video signal. However, when operating below threshold, a 1dB increase in C/N will cause several dB improvement in the video S/N. As the FM detector is non-linear, it is easy to understand when operating in the non-linear portion of FM threshold, impulse noise is introduced at a rapid rate.

Low Threshold Receivers-analogue

Most modern receivers are sophisticated microprocessor controlled units, employing the combination of a low noise figure tuner module and switched IF bandwidth reduction to improve recovery of weak signals.

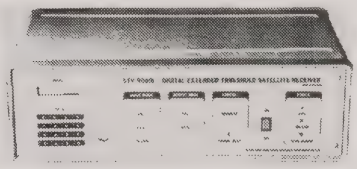
However, a manually tuned satellite receiver is still a good and economical introduction to satellite TV reception. For those inclined to "do it yourself", the Av-Comm kitset receiver was introduced in 1995.

DIY satellite receiver kit

During 1994/5, a number of commercial low threshold receivers were introduced to the world market.
The main advantage of such receivers is the ability to memorise IF bandwidth settings for individual satellite channels, making operation virtually transparent to the end user.

Through the use of variable bandwidth demodulators, PLL detectors and video RAM specialised receivers have been produced than are apparently able to produce entertainment quality audio and video outputs from an input as low as 2dB C/N!!

Many modern low threshold receivers also have sufficient micro-processor power to memorise dish positions.



Super low threshold receiver

Dedicated low threshold digital receivers are available at huge prices. A digital low threshold receiver having a threshold of 0.5 dB was made available in the late 1990's for approximately US$5000, and was apparently used in affluent Middle Eastern countries. Despite such performance claims, no such receiver has ever been seen in the South Pacific.

With the introduction and subsequent widespread use of DVB receivers today, analogue reception is limited to a few satellites.

The migration of many services from analogue to digital and the subsequent savings to broadcasters ensure than the last days of analogue satellite TV reception will be soon upon us.

Radio Reception – SCPC

Television is not the only service available to enthusiasts on Australian satellites.

For many years, prior to the introduction of digital satellite links in 1994, many commercial radio services

Dish Accessories

were accessible on the Aussat A series satellites.

Generally, these broadcasts were dedicated links from capital cities to regional radio stations.

The Optus B1 satellite utilises single channel per carrier, or SCPC as it is commonly known, to distribute air traffic control radio links.

These links are narrowband FM, horizontally polarised, and can be readily demodulated using a UHF scanning receiver. The Optus B series transponder chart shows SCPC services residing on transponder 9.

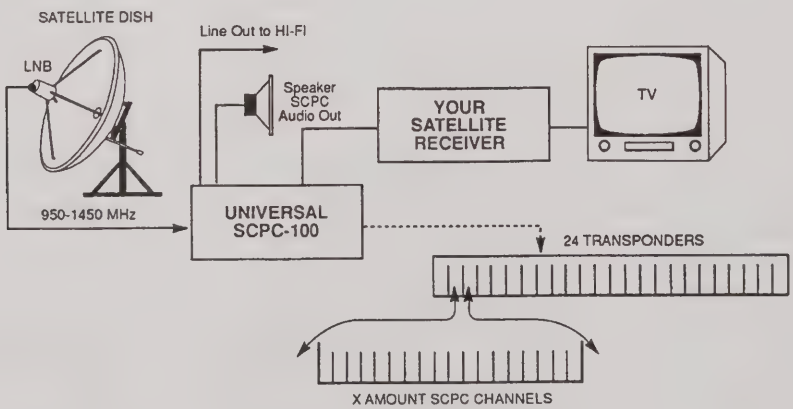
Calculation of the IF frequencies at the limits of the transponder frequency shows that the system LNB produces an IF output from 995 to 1035 MHz, a block of frequencies capable of supporting many NBFM signals.

By connecting a suitable scanning receiver capable of covering the above frequency range, (and resolving NBFM), to the IF output of the LNB (via a DC isolating splitter), SCPC radio reception can easily be achieved.

Of course, the use of a PLL stabilised LNB ensures that radio frequencies entered into the scanner memory, can be accessed at any time, regardless of outside air temperature. Non stabilised LNB's drift, making memory operation of a scanning receiver difficult.

Dedicated SCPC receivers are available, such as the UNIVERSAL SCPC-100. This unit allows series connection of the coaxial cable from the dish, allowing both the SCPC receiver and the TVRO receiver to be connected to the one feeder cable. The LNB is fed, as it would normally be, by the DC voltage supplied by the TVRO receiver.

Despite the introduction of digital services these signals still provide a source of SCPC communications services to the satellite enthusiast.



SCPC receiver hook up

Satellite Related Internet Sites

PROGRAMMERS

ABC (Australia)	**www.abc.net.au/tv**
ABC Asia Pacific	**www.abcasiapacific.com**
ABS-CBN	**www.abs-cbn.com/htdocs/**
AFN (Armed Forces Network)	**www.myafn.net/**
Al Alam News Channel	**www.alalamnews.com/**
AL- Jazeera Satellite Channel	**www.aljazeera.net**
Anhiu TV	**www.ahtv.com.cn/**
Anteve	**www.anteve.uinet.net.id/**
APTN	**www.aptn.com/aptn/copystore.nsf**
Arirang TV	**www.arirangtv.com/english/index.asp**
ART Australia	**www.art-tv.net/channels/art_australia.asp**
ATN Bangla	**www.atv.com.fr**
Asia Plus	**www.asiaplus.com/**
Bali TV	**www.balitelevisi.com/**
BBC	**www.bbcworld.com**
Bloomberg TV Asia	**www.bloomberg.com/asia/products**
Bloomberg Radio	**www.bloomberg.com/radio/**
Canal+ Caledonie	**www.canl.nc/index.php?op=edition**
CCTV(Central China TV)	**www.cctv.com**
CETV	**www.cetv.com**
Channel News Asia	**www.channelnesasia.com**
CNBC Asia	**www.cnbcasia.com.sg**
CNN	**www.cnn.com**
C-SPAN	**www.c-span.org/**
CTN	**www.com.cn**
Da Ai TV	**www.26546000.tv/**
Discovery Channel	**http://asia.discovery.com/home**
Disney Channel	**www.disney.go.com/**
Dubai Business Channel	**www.dubaitv.gov.ae/**
Dubai Sports Channel	**www.dubaitv.gov.ae/sports**
DW	**www.dw-world.de/**
EDTV	**www.dubaitv.gov.ae/edtv/**
EMTV	**www.emtv.com.pg**
East Asia Satellite TV	**www.eastwebtv.com/**
ESPN	**http://espn.go.com/main/html**
EWTN	**www.ewtn.com/tv/**
ETV(Educational Television Station)	**www.nfe.go.th/etv/**
Fashion TV	**www.ftv.com/FashionTV.htm**
Fox News Channel	**www.foxnews.com/**
Fujian TV	**www.setv.fj.cninfo.net/**
Guangdong TV	**www.gdtv.com.cn**
Guangxi TV	**www.gxtv.com.cn/index.php**
GWN	**www.gwn.com.au**
Henan TV	**www.hntv.ha.cn/**
HeiLongJiang TV	**www.hljtv.com**
HRT (Croatia)	**www.hrt.hr/htv/**
Hunan TV	**www.hunantv.com**
IMPARJA	**www.imparja.com.au**

Satellite Related Internet Sites

Indosiar	**www.indosiar.com/**
Indovision	**www.indovision.co.id**
Indus Music	**www.industv.net/241202/index2.asp**
IRIB	**www.irib.com/**
Jame Jan Network	**www.jame-jam.net**
Jiangsu TV	**www.jstv.com.cn**
Jiangxi TV	**www.jxtv.com/**
Kuwait Space Channel	**www.moinfo.gov.kw/eng/freq/space/htm**
Liaoning TV	**www.lntv.com.cn/**
LBC Australia	**www.lbcsat.com.lb**
MAC TV	**www.cts.com.tw/mactv/**
MSTV	**www.5stv.com**
MTA International	**www.alislam.org/mta/**
MTV	**www.mtv-china.com**
Much TV	**www.eracom.com/muchtv.asp**
Nau FM	**www.naufm.com.pg/**
NBN (National Broadcasting Network)	**www.nbn.com.ph**
NET 25	**www.net-24.com**
NIME World	**www.actyvision.com/nimeworld/**
NITV	**www.nitv.tv.main.htm**
NHK	**www.nhk.or.jp**
Now TV	**www.now.com**
ORT-1	**www.ortv.ru/**
Phoenix TV	**www.phoenixtv.com/home/index8.html**
Prime TV (New Zealand)	**www.primetv.co.nz**
PTS (Public TV Service Foundation)	**www.pts.org.tw**
PTV	**www.ptv.gov.pk**
Quick Channel	**www.quickchannels.com**
Radio Australia	**www.abc.net.au/ra/**
Radio Netherlands	**www.rnw.nl/cgi-bin/home/enhome.pl**
RAI	**www.international.rai.it/tv/**
RAI Radio	**www.international.rai.it/radio/**
RCI (Radio Canada International)	**www.rcinet.ca**
RCTI	**www.rcti.tv/**
RDP (Radio Portugal)	**www.rdp.pt/antenna1/index.html**
REE (Radio Spain)	**www.rtve.es/rne/ree/index.htm**
RFI (France)	**www.rfi.fr/**
RFO (France)	**www.rfo.fr/index_ie15m.php**
RTM(Malaysia)	**www.rtm.net.mu/**
RTPi	**www.rtp.pt/rtpi**
SABe TV	**www.sabetv.com**
SCTV	**www.sctv.co.id/**
Shandong TV	**www.sdtv.com.cn/main.htm**
Star Sports	**www.startv.com.hk/eng/frame_schedule.cfm**
Star TV	**www.startv.com/eng/index.cfm**
STV Biz Channel	**www.stv.sh.cn/channelbiz/bizchannel.htm**
Sun TV	**www.chinasuntv.com**
Super TV	**www.supertv.com/tw/**

Satellite Related Internet Sites

Swara TV	**www.swara.net**
Tech TV	**www.techtv.com/techtv**
Thai Global TV	**www.thaitvnetwork.com**
TPI (TV Pendidikan Indonesia)	**www.tpi.co.id**
Trinity Broadcasting Network	**www.tbn.org/home_flash.htm**
TVB	**www.tvb.com**
TVBS	**www.tvbs.com.tw**
TV Chile	**www.tvchile.cl**
TV5	**www.TV5.org/TV5site/home/accueil_inter.php**
TVe1	**www.rtve.es**
TVRI	**www.tvri.co.id**
TVSN Australia	**www.tvsn.com.au**
TVSN China	**www.tvsn.com.cn**
VOA	**www.voa.gov**
VTV	**www.vtv.org.vn/vtv**
WINWEST (Australia)	**www.wintv.com.au/newwin**
World Media International	**www.worldmedia.com.au**
Worldnet	**www.ibb.gov/worldnet**
WRN (World Radio Network)	**www.new.wrn.org/listeners/stations/station.php**
YLE Radio Finland	**www.yle.fi/rfinland/se_satelli_ocj_internet.shtml**
YTN (Seoul)	**www.ytn.co.kr**
Zee TV	**www.zeetelevision.com/newzee/zeehome.htm**
3ABN (3 Angels Broadcasting Network)	**www.3abn.org/television**

SATELLITE OPERATORS

Americom	**www.ses-americom.com**
APT Satellite	**www.apstar.com**
Asiasat	**www.asiasat.com**
Chinastar	**www.chinastar.com.cn/english**
ESA	**www.esrin.esa.it**
India Space Research Organistaion	**www.isro.org**
INTELSAT	**www.intelsat.int**
JSA	**www.jsat.net**
Mabuhay Phillipines Satellite Corp	**www.mabuhaysat.com**
Measat	**www.measat.com.my**
NewSkies Satellite	**www.newskies.com**
Optus	**www.optus.com.au**
PANAMSAT	**www.panamsat.com**
RSCC (Russia)	**www.rscc.ru/eng/zone04.htm**
Russian Space Agency	**http://liftoff.msfe.nasa.gov/rsa/rsa.html**
Satelindo	**www.satelindo.co.id**
Singtel	**http://welcome.singtel.com/default.asp**
Sino Satellite Communications	**www.chinanex.com/company/satellite/sinosat.htm**
TARBS	**www.tarbs.com**
Thaicom	**www.thaicom.net**
TNS (Tahiti Nui Satellite)	**www.tns.pf**

Satellite Related Internet Sites

MODULATION SYSTEMS-ANALOGUE

Virtually all analogue encryption systems have now been superseded by digital encryption. The descriptions presented here are for historical interest. All are variations of the cut and rotate principle.

Video crypt

Video crypt is an encryption system designed primarily for use with the PAL transmission mode. It was developed in 1988 by Thompson Consumer Electronics in France, and Professor Adi Shamir of the Weitzmann Institute of Science in Israel.
Video crypt was used by the terrestrial "Sky TV" service in New Zealand, and by Television Oceania, a Japanese language narrow caster utilising the Optus B3 satellite, until the termination of service in March 1996. PNG broadcaster EMTV, operating on the Gorizont 30 satellite used the Video crypt system for several years from 1996.

Videocrypt decoder

Further afield, the system was used by Sky Television in the UK.

Video crypt is so robust it is possible to record the encoded signal and play it back for decoding. Professor Shamir came up with the concept of zero knowledge transfer, which has been explained by Thompson's R and D lab as follows:

"To decode the signal, the code coming down from the satellite with the program cooperates with codes stored in the decoder and codes stored in a smart card, to create a digital signature. There is no single secret code to crack".

Video crypt achieved what many people had previously thought impossible. It encrypted a PAL signal with almost total security yet without noticeably degrading picture quality after decoding.

Also, although address codes are broadcast with the picture signal, they are not essential to authorisation. The key role is played by the smart card with its built-in computer and memory chip. Hence, there was no need to leave receiver switched on unless it was for some other reason, to keep the LNB stable, etc.

Video crypt operation is as follows.

Before transmission, each horizontal line of the TV picture is cut into two halves and these are rotated so that the second is transmitted before the first.

There are several hundred possible cut points in each line and these continually change. On a conventional TV set, the received picture appears as a meaningless jumble of horizontal streaks. This is the technique known as "cut and rotate". The decoder delays each line of the picture just long enough for the two halves to be inverted and joined to reconstruct the original picture line.

However, the decoder can only do this if it receives the correct instruction on where each line has been cut.

Part of this vital instructional key, is transmitted like Teletext as a digital code carried in the vertical blanking interval. The code in the vertical blanking interval has a slower data rate than the teletext. This is to make it more robust. The other part of the key is stored in the solid state memory of a smart card. Once the card has been fitted to a decoder, the decoder will de-group pictures until the transmitted code changes and the subscriber inserts a new card to match the new code.

The card system works by chaining handshakes. All decoders are the same, like an un-programmed computer. Each card carries an identification number matching the subscriber. When the first card is initially inserted into a new decoder, its number is stored and the decoder authorises the card for use. The authorised card can then be used in any decoder. When the card expires, the new one must be first inserted into the home decoder,

which checks the number of the new card and authorises it for use in any decoder and so on.

Each decoder, therefore only works while it has an authorised card. When the transmitted codes change, the user needs a new card. Because each card is coded to match the identity of the subscriber, if a card is lost during delivery or stolen it can be easily disabled through an instruction transmitted in the satellite signal which can permanently disable that single card.

Crypto vision

The Crypto vision system is similar to "Video crypt", as it uses a similar cut and rotate system. Each active line of video is cut at a random point and the two line segments formed are interposed.

The first part of the line is shaped with a sine squared ramp, and the cut point is shaped with overlapping sine squared and cosine squared ramps, added together.

The last part of the line is shaped with a cosine squared ramp. This means that in the event of the rotated portions of the line forming a transition from black to white, (or reverse white to black), on adjacent pixels, that the bandwidth required is under 5MHz instead of the 25MHz or so normally required.

The audio signal is also scrambled using spectral inversion. The Crypto vision system is capable of addressing up to 128 million decoders in the same system.

There is a security processor in each decoder, capable of processing the algorithms for decoding the signal and the serial number of every individual decoder.

The encoder transmits a "control message" to all decoders once every two seconds, as well as decoder "entitlement messages", which are sent at a rate between 17000 and 22000 per hour.

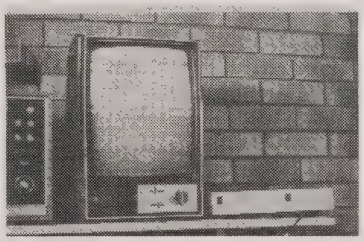
In Australia, the Crypto vision system was used by the Victorian Department of Secondary Education to transmit educational programs to schools in Victoria during the late 1990's.

Vidiplexing

Vidiplexing is a system developed by Thomson CSF, which allows two independent video frames to be transmitted in interlaced format, simultaneously, as a type of analogue compression. Although used infrequently since the introduction of MPEG, the system was used extensively on Intelsat 508 (later replaced with I 511) by several commercial networks in Australia.

The system utilises two sequential fields of a TV signal (normally carrying identical video information) to carry two separate and different video signals. In effect, it allows two pictures and their accompanying audio sub carriers to be transmitted at once, eliminating the need for additional transponder hire for the second program.

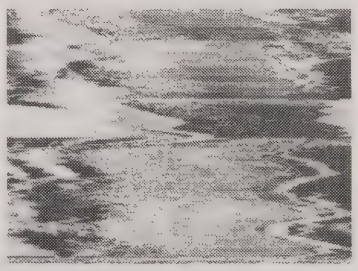
Another inexpensive method of viewing both frames simultaneously, was to use a standard video monitor, and rotate the yoke 90 degrees. By then rotating the monitor through 90 degrees, so that it sat on its side, the two frames were displayed vertically, provided there was sufficient range in the vertical hold adjustment.



Inexpensive Vidiplex display

B-MAC

B-MAC encryption offers hard video security through a technique known as line translation scrambling. Each line of video information is delayed by several microseconds, creating B-MAC's characteristic diamond shaped pattern.



Distinctive B MAC encoded video

Only receive stations equipped with a B-MAC decoder can descramble this signal. Such decoders are addressed by a packet of data contained in the vertical blanking interval of the B-MAC signal.

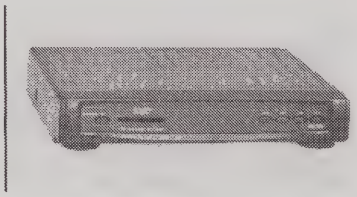
The B-MAC horizontal blanking interval contains up to six digitally encrypted audio channels on one spare data channel. In addition, B-MAC provides an increased level of signal performance at low carrier to noise levels when compared to PAL.

This results in the use of smaller diameter dishes, compared to other analogue transmission formats.

B-MAC sequentially transmits colour information in one third of the active scanning time of each frame, and black and white information in the remaining two thirds of the active scan time. This prevents chrominance and luminance interference, providing improved video performance.

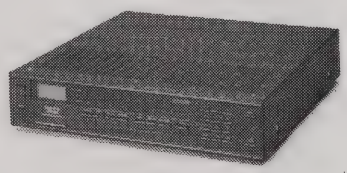
By displaying the video vertical blanking interval, individual lines that carry signals can be observed. Line one is used for the digital clock recovery signal, whilst line two carries digital sync, line three is used for the transmission of system data, lines four, five, six, seven, eight and nine are used as address lines for data packets whilst lines ten, eleven, twelve, thirteen, fourteen and fifteen are used to transmit teletext packets.

The horizontal blanking interval can contain as many as six 204 kilobytes per second (kb/s) digital audio channels and one 63 Kb data channel. B-MAC was utilised by Indonesian broadcaster INDOVISION to carry subscription programming to authorised viewers in the region. The B-MAC decoder used for this service was the CDE-2000, which utilised the base band output signal from an analogue satellite receiver.



Indovision BMAC decoder

In Australia B-MAC was utilised to carry television and radio services to outback residents, from 1985 to 1998. In 1996 we wrote "with the likely introduction of digital video compression services in the next few years, the future of B-MAC on Optus and Palapa would optimistically seem to be limited to the next 5 years".



Scientific Atlanta #9708 BMAC decoder

E-Pal

In addition to the RABS services carried on the Optus satellites, up until 2002, commercial networks distributed their programming using a unique encryption system called E-PAL.

The use of this system was twofold: it enabled television networks to comply with government regulations ensuring that reception of commercial TV signals by satellite was prevented, thereby protecting regional TV stations and ensuring their continued operation (and income from local advertising), and it also provided enhanced audio dynamic range and fidelity, through the use of ADM (adaptive delta modulation).

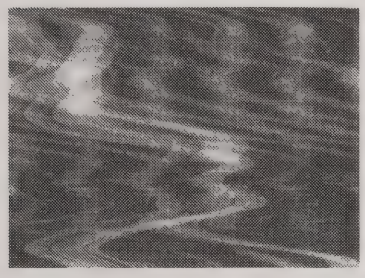
E-PAL works by digitising the audio through the use of ADM, and by corrupting the vision signal by inverting the video, and removing the sync signal.

During the 1990s satellite enthusiasts produced a variety of homebuilt E-PAL vision decoders. Unfortunately, no economical decoders were ever devised to produce audio from E-PAL.

The results of these efforts demonstrated that the combination of terrestrial TV sound (even though the picture might be unrecognisable), and E-PAL vision by satellite, provided an imperfect solution for those unable to view terrestrial commercial television signals.

Sinewave Sync Shifting

This is a relatively simple encryption system, once employed by at least one operator on the Palapa series of satellites. The video signal is inverted, and a sinewave at either 60Hz or a multiple of 60Hz (in countries using NTSC, such as the Philippines) is added to the inverted video.



Sinewave Sync Shifting before decoding

The result is deflection of both the vertical and horizontal and sync signals into the luminance signal, making it impossible for the video monitor or TV set to lock to the frame.

MODULATION SYSTEMS-DIGITAL

Video Compression

Video compression is the technology used for satellite delivery of Australian "Pay TV" services. The main advantage of video compression is the operating cost. If 24 video compressed channels can be transmitted by satellite using just a single transponder, then each channel operator is up for one twenty fourth the cost of a full transponder.

As the single transponder cost per 12 months is likely to approach $7 million, this is a considerable saving.

Digital video compression for broadcast services offers the vastly improved transmission capacity at greatly reduced cost. MPEG-2, the latest compression standard, assigns the highest priority to image quality, and is designed to handle full screen, full motion images, at data rates of up to 40Mbits per second.

Almost all of the work to set an international video compression standard has been done by the Motion Picture Expert Group (MPEG), the International Standards Organisation (ISO), and the International Electrotechnical Commission (IEC).

In April 1993, after 4 years of work, the 230 MPE members from 18 countries agreed on the architecture of MPEG-2. In November 1994, MPEG-2 was designated an international standard, and US, European, and Japanese chipmakers started chip sampling.

Since that time hundreds of manufacturers have flooded the international market, causing prices to drop dramatically.

The average price for a digital satellite receiver in 2002 was half that of the 1998 price.

For those sceptical about data compression and the results with MPEG-2, the results are astonishing. MPEG-2 can compress images of much higher quality than those of analogue TV broadcasting.

This is the driving force behind the introduction of digital terrestrial television.

MPEG-2 is a completely different approach to traditional data compression, which aims to use as little bandwidth as possible, whilst providing the highest possible resolution.

The whole concept of data compression relies on eliminating the repetitive bits of information in a moving picture that do not add to picture content. By eliminating as much unwanted data as possible, narrower bandwidth can be used. The first compression standard, intended only for still pictures, and subsequent storage on either magnetic or optical disk, was JPEG, developed in 1991.

Subsequently MPEG-1 was developed, assuming that compressed data would be stored on a compact disk, with a transfer speed of 1.2Mbits per second. This allows reproduction of video, at quality almost equal to VHS tape. By updating data at a sufficiently high rate, smooth flowing motion can be achieved. At data rates below 1.2Mbits per second, jumpy motion cannot be avoided, making systems using this low rate of compression, ineffective for fast moving programming such as sports etc.

MPEG has a layered structure. The outer layers provide the system functions, synchronisation and multiplexing, necessary because of the multiple data streams used in the system.

The inner layers define image and audio compression mechanisms.

The MPEG-1 system works by recognising that pixels change little from frame to frame in moving video images. The system takes a reference frame, compresses it, performs a transform and then quantises the frame. This four step procedure retains all the information, thus maintaining reasonable quality.

The system then takes a new reference frame, every quarter of a second or so, depending upon the level of pixel movement. In between reference frames, the system transmits vectors to signify which areas in the frame have moved, and in what direction. Between the motion vectors, predictions are made to determine where the next movements will occur.

MPEG-2 on the other hand, combines high resolution and narrow bandwidth, and is designed to be used where image resolution and quality is critical.

MPEG-2 uses DCT for intra-frame compression and "motion estimation" for frame to frame compression. Both processes operate on an 8 by 8 pixel area, called a block. The MPEG algorithm is built around a discrete cosine transform (DCT) algorithm. This transform produces a two dimensional spectrum of the image, and allocates a priority to the contents of the spectral analysis, in order of importance relative to human perception of the image.

The most important components are sent with high resolution, the lesser important components in low resolution, some not being sent at all. As this system intentionally deletes bits of information, it is known as a "lossy" compression method.

Specifically, the DCT method breaks the video signal up into blocks of 8 by 8 pixels. These blocks are then transferred from the spectral domain to the frequency domain by implementing a cosine transform, which is similar to one half of a Fourier transform. In the frequency domain, elements that are not visible to the human eye can be removed.

The next step in compressing an image is "motion estimation". This is a system where an instruction can be sent, commanding a block of pixels to be moved from one position to another. This saves resending the entire frame. So, once the signal blocks are transformed, motion estimation is performed, where the system tries to determine whether a block has either moved or changed.

The amount of compression that can be achieved by motion estimation depends upon the area of motion on which the search is performed. Depending upon the amount of computational power available, motion estimation can range from adjacent blocks of pixels, to the complete image.

Because the DCT technique is extremely intensive, a high level of computational activity is required, equating to high cost for the encoding equipment. This is one of the deficiencies of the MPEG scheme, but fortunately decompressing hardware is relatively simple.

MPEG-2 is also designed to support the American Information Superhighway, and can be interfaced with the next generation communication/computer network, using ATM (asynchronous transfer mode), as well as HDTV.

There are several chipset suppliers, all developing third generation MPEG-2 decoders, all with enhanced functions. Amongst those functions are: on screen display (OSD) which will be used to display program guidance messages, a "3:2 pull down" function allowing users to covert 24 frames per second movies to 30 frames per second for TV, and a "pan/scan" function allowing users to convert an image with an aspect ratio of 4:3 into a 16:9 wide screen image.

In fact the latest version MPEG satellite receivers also incorporates a hard disk drive for recording off air programming. This feature is called the personal video recorder (PVR). Future receivers incorporating a PVR will also include a predictive determination engine (PDE) capable of analysing viewer recording habits and anticipating the type of programs the viewer would like to record.

In the absence of human intervention the PDE will automatically record such programs.

In addition to the MPEG-2 LSI chipset, decoders will require up to 64Mbits of DRAM to store images of the highest quality (720 x 480/576 video).

The universal adoption of DVB compliant MPEG 2 receivers, means that very few alternatives ever made it to market.

In Australia, the now defunct Pay TV operator Australis Media (Galaxy) initially announced they would be using general Instruments Digicypher 2 video compression system.

However, some months later this decision was scrapped and the company committed to DVB compliant set top boxes from English manufacturer Pace.

The present Pay TV satellite operators Austar and Foxtel utilise the MPEG2 video compression system.

Elsewhere in the Pacific, Hong Kong broadcaster TVB began using the Digicypher system to deliver programming to cable operators in Taiwan, whilst a group of broadcasters using the Panamsat PAS-2 and PAS-8 satellites have adopted the Scientific Atlanta MPEG-2 proprietary format, using their "PowerVu" decoders.

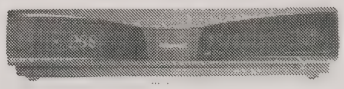
DVB Compliant MPEG Decoders

In late 1995 there was an initial push by European broadcasters to produce a single, and universal standard for digital transmission (satellite or terrestrial) using the MPEG format.

Prior to that time, a number of manufacturers, predominantly in the USA (General Instruments, Scientific Atlanta) had produced their own proprietary MPEG decoders for dedicated closed user systems.

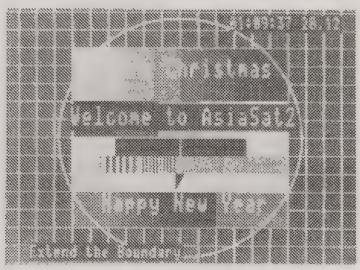
Scientific Atlanta PowerVu decoder

By early 1996, most European broadcasters had agreed to adopt "DVB compliant MPEG" as the digital standard of the future. The first manufacturer to produce a DVB compliant MPEG IRD was UK maker PACE, who produced their DGT-400 for Australis Media's Galaxy TV, the first Pay TV operator in Australia.



Panasat digital decoder

By 1996, Multichoice, a Pay TV operator in South Africa had also commenced MPEG operations using locally produced DVB compliant Panasat decoders, subsequently manufactured by UEC in South Africa.



Digital signal from Asiasat 2 Jan 1996

Proprietary MPEG systems are not immediately compatible with DVB compliant decoders, and DVB compliant decoders offer significant advantages to the user over those earlier, non-compatible models.

All programmers using the DVB standard have a common bit stream mapping system and a common access code processing system.

This means that any programmer using a DVB stream will be able to address any DVB compliant receiver, regardless of the source or brand.

Theoretically, if all broadcasters cooperated, any DVB receiver could be used for any digital broadcast, once authorised by the broadcaster, offering the service.

Conditional Access

Presently, the most prolific conditional access system (CA) is that designed by Dutch company IRDETO.

First developed in Holland over 30 years ago, the original IRDETO scrambling system was called Luxcrypt, utilizing a synch pulse replacement system, and was widely used in Europe for analogue signal encryption until the mid 1990's.

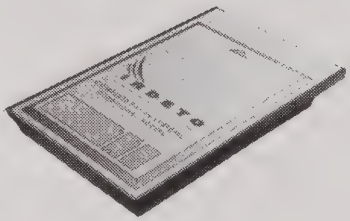
Mindport acquired the system in 1996, and most broadcasters in Australia have adopted the digital version M-Crypt.

Capable of processing MPEG-2 data at 54 Mb/s, Irdeto's Conditional Access Module descrambles the MPEG-2/DVB data stream and filters off ECM's and EMM's (Entitlement Management Messages) under the control of the smartcard.

All communication with the smartcard is via the CAM. As well as inputs and outputs for the scrambled and unscrambled MPEG-2 data, the CAM has serial bus connections to the smartcard and the Integrated Receiver Decoder (IRD).

The CAM is implemented as a PCMCIA-3 module that plugs into the IRD via a simple interface to the IRD circuitry. This approach has several advantages. It makes a universal IRD platform possible for all territories, therefore allowing economies of scale for manufacturing both IRD and CAM.

Hence, technology upgrades can be simply undertaken by replacing the CAM in the field.



Irdeto CAM

A further advance on the CAM is the Common Interface Module (CI module).This is a PCMCIA module that provides a complete platform for various CA systems.

In this way, a DVB receiver can be used with several CA systems, through the use of a CI module and smartcard for each encryption system. The smartcard in inserted into the CI module, and the CI module is inserted into the receiver.

Irdeto CI module

A conditional access module (in addition to a subscriber smartcard) is required in conjunction with an MPEG receiver for subscription services.

There are other Conditional Access systems employed by broadcasters operating in our part of the world.

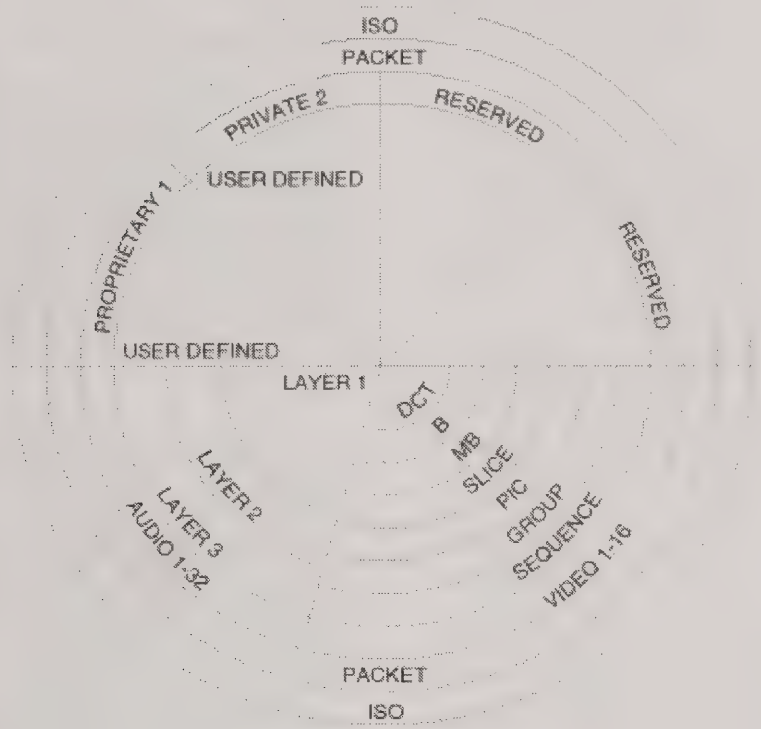
For instance there is a French language Pay TV service called LBF (Le Bouquet Francais) for which a subscription can be obtained for Australian viewers. That service uses a conditional access system called "Mediaguard". Both Common Interface and dedicated embedded receivers are available for the service, which also relies on a subscriber smartcard for security.

Several broadcasters using the NSS-6 satellite use Viaccess encryption.

Australian Pay TV broadcaster TARBS uses a dedicated and unique CA system called "Mentor" which uses a matched receiver and smartcard for added security.

Scientific Atlanta have developed a secure embedded conditional access system called "PowerVU". This CA system is used on by many broadcasters on the Panamsat 2 and 8 satellites.

However many services (the hundreds of free to air signals on C band satellites receivable in the Pacific) require neither smartcard, CA module or dedicated receiver for reception.



MPEG layered structure

The reception of digital signals is somewhat more complicated than a simple analogue receiving system, and any errors in the received data can result in unacceptable breakdown of the picture into mosaic components or even complete freeze frame. To understand why this is so, a simplified explanation of the theory behind transmission of digital signals is necessary.

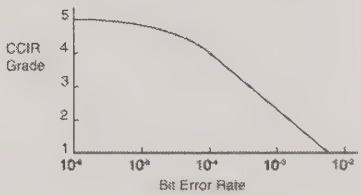
Theory

In the late 1940's, a US engineer, Mr Claude E Shannon produced an "Information Theory" pertaining to data transmission, that showed that the capacity of a digital channel is determined from the number of data bits per second that can be transmitted with an acceptably low bit error rate.

The capacity of the channel is a function of the bandwidth and the available signal to noise ratio. This theory is of great use to communications engineers, as it provides a method of determining the achievable limits over a given communications link. In order to minimise the amount of data lost due to signal distortion over the transmission path, and through the non linear parts of the receiver, Forward Error Correction (FEC) is used to add extra bits of information to the data stream. These are added in a predictable way, so that the decoder can utilise them to assist in data recovery.

In digital systems, the equivalent to the Signal to Noise ratio, is Eb/No, defined as the energy per information bit, to noise density ratio. For every specific modulation and encoding system in use, there is a value of Eb/No which corresponds to the expected Bit Error Rate at the decoder.

Subjective tests have shown that a BER of 10-6 or better is required for the equivalent of CCIR grade 5 video quality.
The following graph shows the relationship between Bit Error Rate and video quality. Digital receiving systems are far less forgiving of low signal or poor cross polarisation, and particular care must be taken with these two aspects of a home satellite TV system.



Relationship between CCIR and BER

Preparatory Work

There are many satellites visible from Australia, all with varying power levels and program content. In order to set up a satellite earth station that will provide satisfying results, it is important to carefully consider the available satellites and their suitability. This will

Setting up a Satellite TV Receiving System

determine the required dish size, and operating band.

At present, there are also government regulations in place, preventing overseas broadcasters offering Pay TV services direct to the Australian general public.

By convention, C band is used by international broadcasters, whilst K (or Ku) band is generally used for domestic satellite transmissions.

Presently, there are six sources of accessible free to air Ku band signals, typically Optus B1 and B3 and Panamsat 8 and 2 satellites. Intelsat 701 carries a single to air channels as part of the LBF bouquet, whilst NSS-6 carries a dozen or so foreign channels.

Many free to air services are carried on the Optus B3 "Aurora" service, including the ABC and SBS services in most states.

Optus "Aurora"

Since 1985 there has been a satellite TV service providing ABC, SBS and several regional stations to viewers in areas not serviced by normal terrestrial services.

In the past this service was called the HACBSS (Homestead and Community Broadcast Satellite Service) and used an analogue modulation system called BMAC.

This system provided selective geographic access to the free to air channels, and encryption for closed networks such as Sky Channel and other users, and operated on the Aussat A3 satellite for thirteen years.

In 1998 the new digital "Aurora" system commenced operations, on the Optus B3 satellite, offering a far more powerful signal and superb digital quality picture and audio quality.

The B3 satellite was replaced by the Optus C1 satellite in 2003, providing even stronger signals across the country. Most areas are now covered using dishes of 1.2m or less. Pay TV operators have even stronger signals (concentrated on the populated coastal areas) and utilise 65cm dishes.

The new service uses Digital Video Broadcasting (DVB) which involves the use of MPEG compression. Like all things in modern times, (mobile phones, terrestrial TV etc) satellite technology has also progressed from analogue to digital.

There are advantages for both broadcaster and viewer alike through the use of MPEG. The main advantage to broadcasters is that the new digital service uses less spectrum, and hence costs less to operate per channel.

The advantage to viewers is that more channels can be made available at the same price (as analogue).

The stronger signal means that systems sold today are able to use much smaller dishes than previously was possible.

The smaller dish means a much lower price, making such a system easily available to remote area travellers, mobile home and caravan owners and even those who cruise our inland waterways!

Photo courtesy Marine Sentinel

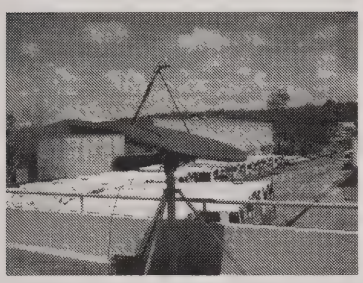
Unlike terrestrial TV, which is affected by the topography of each location, satellite TV requires a clear view of the relevant portion of the sky to operate successfully.

In some instances it may be preferable to mount the antenna in such a way so as to minimise wind resistance.

Using an offset dish this can be achieved by mounting the dish horizontally. This is an ideal solution for travellers wishing to transport their dish "in situ", minimising the height above the vehicle. A shroud can be employed to minimise the affect of wind during transit periods.

The feed struts can easily be re-attached when

satellite reception is required!!



Offset dish mounted for minimum wind resistance

Pay TV has enjoyed some success in the more populated areas of Australia, however for viewers located in "the outback", the technical effort required to receive those services far outweighs the benefits.

The Aurora service uses a national beam giving a more even signal over Australia, whereas Pay TV operates on a dedicated spot beam, covering a limited area specifically aimed at the more populated regional areas of Australia.

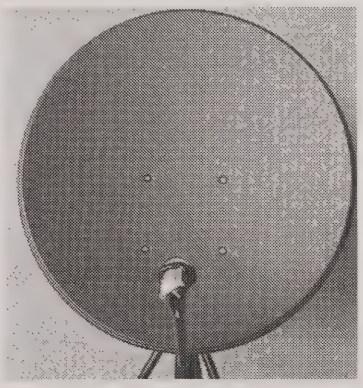
As an example; Australia's satellite Pay TV operator for country areas, Austar, uses an 11 metre dish to pick up signals from their own network in Alice Springs for local rebroadcast using a microwave service.

To receive the Aurora service in Alice Springs a 120cm dish is all that is required.

In a stark contrast to Pay services, "Aurora" utilises a national footprint allowing much smaller dishes to be used in areas outside the populated east coast of Australia. There is also the added advantage that the service is free!

An Aurora receiving system comprises an 85cm dish (suitable for most areas), an amplifier (called an LNBF), a digital receiver, a smartcard and coaxial cable.

Even though the service is free, it does run under conditional access. The use of a smartcard registered to the end user and his geographic location, ensures that viewers cannot receive programs outside the license area of the broadcaster.

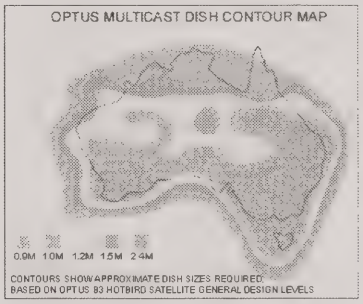


Typical 85cm offset dish with LNBF fitted

This is done to protect the owner of program copyright and regional terrestrial broadcasters.

Apart from a number of closed "subscriber only" services, the ABC operates services in Queensland, Northern Territory, Western Australia, South Eastern Australia, (NSW and VIC). SBS also transmits services in Western Australia, Queensland and South Eastern Australia.

In the far north of Australia, there is some signal drop-off and a larger dish is required. The map below shows the satellite footprint and the dish sizes required.


OPTUS MULTICAST DISH CONTOUR MAP
0.9M 1.0M 1.2M 1.5M 2.4M
CONTOURS SHOW APPROXIMATE DISH SIZES REQUIRED
BASED ON OPTUS B3 HOTBIRD SATELLITE GENERAL DESIGN LEVELS

It is a great advantage to be able to watch ABC and SBS in all time zones, as it means that missed programs on the east coast, can be viewed half an hour later on the South Australian service or two hours later on the Western Australia service. These channels are freely available to anyone purchasing an "Aurora" system. In addition there are over 40 radio stations available.

Licensing restrictions

In certain regional areas of Australia other commercial stations operate via satellite, each with their own licensed coverage area. License areas and operating policies are set by the ABA (Australian Broadcasting Authority).

There are very strict regulations regarding out of area reception of these signals, mostly relating to broadcaster license conditions and program copyright issues.

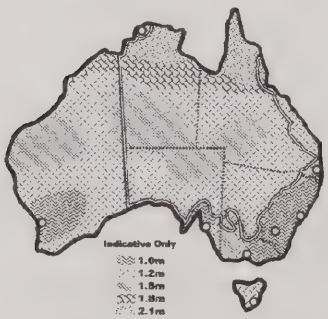
Seven Central, an independent regional

broadcaster, has a license allowing it to broadcast to a satellite audience in areas east of the Western Australia border, see map below (source: 7 Central website: www.sevencentral.com.au.

The lightest shaded area on the following map indicates 7 Central coverage area.

7 Central service area

Imparja is an independent broadcaster located in Darwin, carrying a mixture of Network 9, Ten Network, and their own indigenous programming.



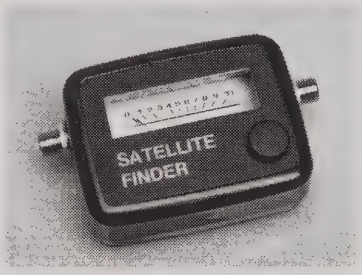
Imparja service area

Their license are also allows coverage east of the W.A border, see map above (source: Imparja: www.imparja.com.au).

Golden West Network is an independant Western Australian broadcaster located in Bunbury W.A. broadcasting to W.A. satellite viewers only.

WinWest TV is a Network 9 affiliate, licensed to service the W.A satellite audience only. There are other services also available such as "Westlink", an educational service provided by the Western Australian government.

Setting up the system is not difficult, the most effort is required to point the dish accurately. Dish pointing information for any location in Australia is easily available from any reputable satellite equipment dealer. Installation can be made easier by utilising a small satellite signal strength meter, called a "Satfinder".



Satfinder

C band-international reception

C band signals can come from a number of satellites including Intelsat, Insat, Apstar, Thaicom, Asiasat, Palapa and Panamsat. All of these can be received from the east coast of Australia, even more are available from the west coast where satellites covering the IOR are also visible.

For C band reception, a good general purpose size dish is 2.3m. This will provide reception from most of the available international satellites.

There are however, some instances where a larger dish is recommended, for dedicated single satellite reception. Footprints for specific satellites should be consulted prior to determining dish sizes. Many can be found in the orbital location data section at the end of this book.

Pointing the Dish

For every location in Australia, there is a different set of "pointing co-ordinates" required to correctly point a dish at a specific satellite. Dish pointing co-ordinates can be calculated using a number of commercial software programs, and most equipment vendors will also calculate these on request, for any location in Australia.

Some computer programs have the ability to print pointing co-ordinates between latitude and longitude limits, simplifying the job of an installer. It is easier to carry a few sheets of paper, than a computer!

All programs require the satellite longitude, and the site latitude and longitude, as well as magnetic variation to perform this calculation, producing a magnetic bearing, a true bearing and the angle of elevation.

Site latitude, longitude, and magnetic variation can

be obtained from the local airport. Most pilot supply outlets carry maps known as WAC (world aeronautical charts) charts, which show these details. The magnetic variation for the earth station site is important because a compass is to be used to help align the dish.

Having decided on the desired satellite and the necessary system components, the dish must be pointed in the correct direction. The dish must have a clear view of the appropriate part of the sky, unobstructed by buildings or trees. The azimuth and elevation settings of the dish are collectively known as the "look" angle.

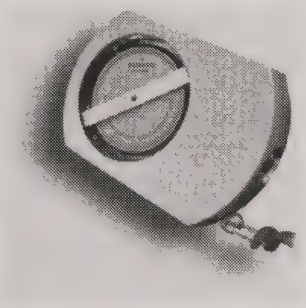
Where reception of multiple satellites is desired, the dish must be sited so that it has a clear view from west to east. For any site there is a limit to the visible horizon. At the equator this limit is +/- 81.3 degrees. This range decreases as latitude increases.

Siting the Dish

It is important that the satellite dish has an unobstructed view of all desired satellites. The dish will not operate at peak efficiency if the signal is even partially blocked by obstructions such as trees, fences, buildings etc.

A visual inspection is always necessary to ensure a clear path. One device especially useful for this purpose is the inclinometer.

Using this device, it is possible to read elevation, and also simultaneously "eyeball" the path, to ensure it is clear.



Inclinometer

Another useful item is the hand held digital flux gate compass. This unit allows the user to display and memorise azimuth headings and has the ability to null out residual magnetic fields, or disturbances caused by localised steel or iron objects.

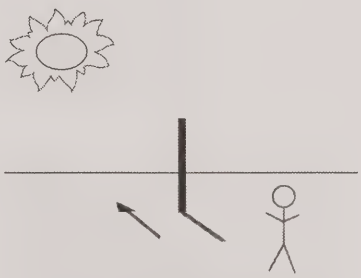
No matter what the type of compass, extreme care should be taken to avoid the effects of residual magnetism caused by the close proximity of magnetic metals, and the resultant errors caused.

Flux Gate compass

Sources of residual magnetism include wristwatches, eyeglasses, cellular phones, pocket pagers, and of course steel dish mounts!!

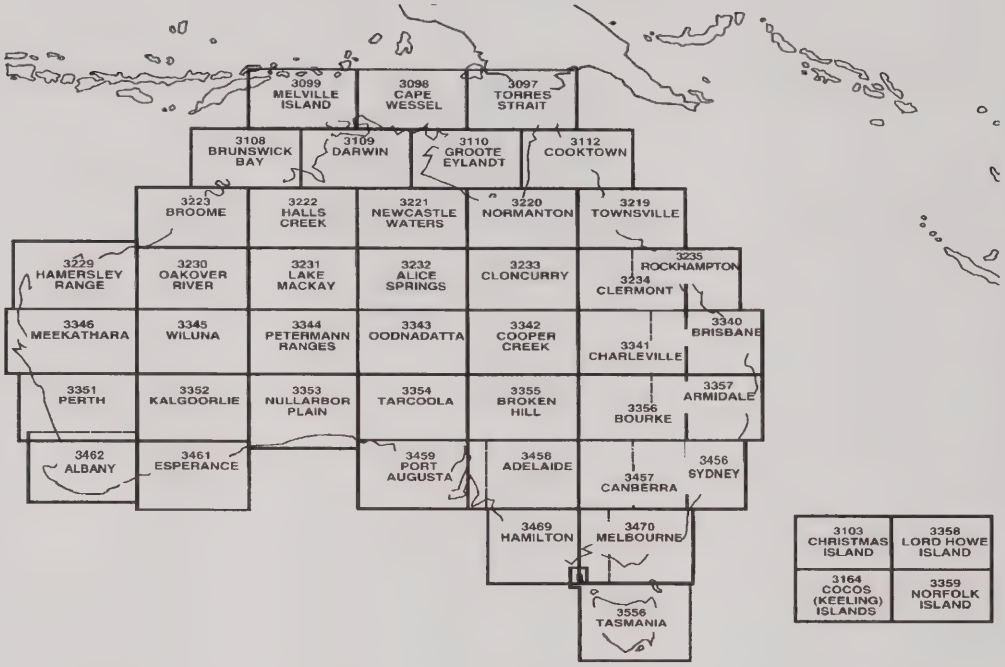
Where it is not possible to physically stand in alignment and close proximity to a dish, the reciprocal compass heading can be used.

By standing well in front of a dish (and away from all metal likely to cause compass errors), and checking the azimuth to the calculated value minus 180°, a more reliable reading can be obtained.

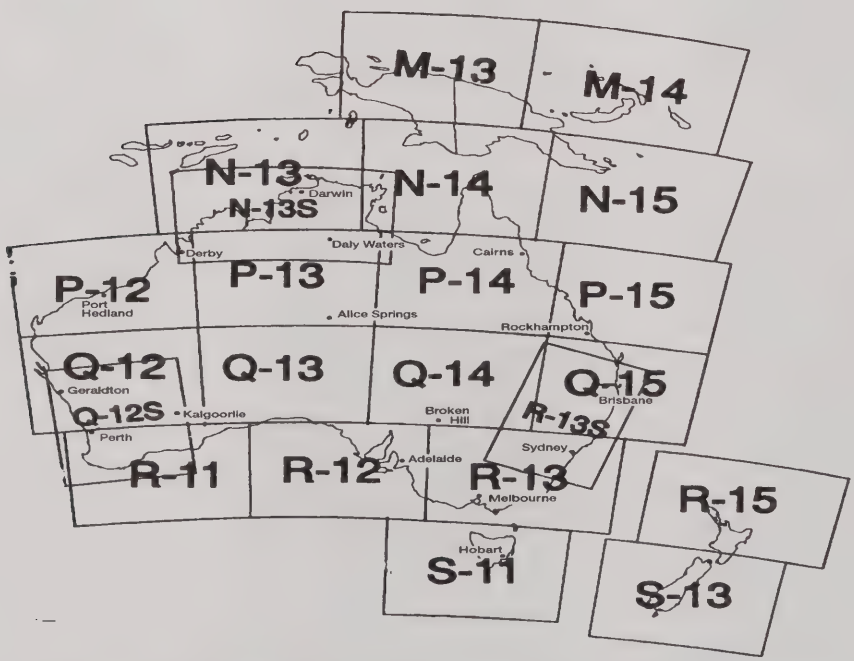


180 degree reverse bearing taken by facing the dish

The simplest method of using this "reciprocal" approach is to line up the compass with the centre of the feedhorn and the mounting post of the dish.



World Aeronautical Charts (WACs) covering Australia



Operational Navigation Charts (ONCs) covering Australia

Setting up a Satellite TV Receiving System

Site Survey

Unfortunately, and especially in our crowded cities, there are many sources of microwave energy that can interfere with satellite TV reception. Also, where a dish is to be mounted on a roof, (where buildings cannot shield microwave interference) there is an increased risk of such interference.

It is hence prudent in many instances, especially where C band reception is required, to carry out a site survey.

In the case of analogue reception, this can be as simple as connecting an LNB to a feedhorn and receiver, and whilst watching the TV screen, sweeping the LNB across the sky in the general direction of the satellite.

Where the satellite channel frequency is known, the receiver should be tuned to that frequency. Where many channels are to be received, this test should be repeated for every frequency.

In the case of digital reception a spectrum analyser should be used to measure any terrestrial interference. Generally, as long as there is no terrestrial signal on exactly the same frequency as a digital satellite signal, reception will not be affected.

If no interference is detected using this method, there is a good chance none will be encountered on a satellite receiving system. The dish adds directivity, and the feedhorn when fitted adds polarity rejection, both of which will reduce terrestrial interference or "TI" as it is known.

For commercial installations, it is always wise to use a small test dish, fitted with LNB and feedhorn (set to the correct polarisation). This combination should be fed, via a power inserter, to a spectrum analyser, where the proposed satellite IF can be monitored, if necessary with a chart recorder for 24 hours. This is the only sure way to predict the level of interference prior to dish installation.

Troublesome Sites

Any site located near an airport which operates navigational aids such as radar, deserves close scrutiny prior to considering the installation of a satellite dish.

Sites located directly in line with, or under aircraft flight paths can be adversely affected by airborne radar altimeters and weather radar. Check these sites carefully using a small dish prior to installation.

Likewise, it is often prudent to check sites located near microwave dish towers for interference.

Although decreasing, there are still a number of 4GHz links along the east and west coasts, and along regional communications routes throughout Australia.

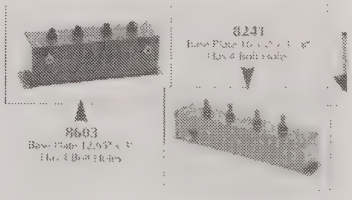
As these microwave links operate at similar frequencies to those used for C band satellite downlinks, they can be a source of interference, which can prevent the reception of all satellite TV signals.

One possible solution, which can be used to minimise terrestrial interference, is the dish shroud. The mesh shroud acts as a shield against TI occurring abeam, or at right angles to the dish. A shroud can be used to advantage in most instances, unless the source of TI is directly inline with the azimuth of the dish.

In such cases relocating the dish so that it is shielded by buildings, may have a more positive effect.

Dish shrouds

Where TI occurs on a single frequency within the satellite band, a microwave notch filter can also be used. Photo below shows examples of such filters.



Setting up a Satellite TV Receiving System

Local council regulations

There is an increasing number of local councils requiring that council approval be given to private individuals prior to dish installation. In rural areas, this is normally no problem, some councils requiring only a sketch from the applicant showing the location of the dish relative to buildings, boundaries etc.

In city areas, this requirement is becoming more of a problem to private individuals, generally requiring the submission of a "development application". The requirement for an official submission seems to hinge on whether or not a satellite dish is classified as a "structure". A temporary ground mounted dish could hardly be classified as a structure.

In some suburban cases, a development or building application will be necessary. Some councils have stated they will not allow private individuals to install dishes, and can issue a legally binding demolition order for dishes installed without approval.

There are two matters with which councils concern themselves, when it comes to dish installations:

Does the installation comply with good engineering standards i.e. is there any public liability? and does the installation have any visible impact on the local landscape?

Both these matters can generally be successfully dealt with, by using a structurally certified dish mount, and often by using visual screening such as shade cloth or lattice to hide the dish.

Whether an individual decides to seek council approval or not, it is wise to consider both matters prior to dish installation.

Since January 2001 the responsibility for obtaining local council approval in many places has been transferred from resident to dish installer. Installers who neglect to obtain approval can be fined and ordered to remove the offending dish.

If a problem is encountered with a local council after dish installation, a personal approach should be made to the appropriate council officer. Generally a mutually acceptable solution can be obtained, although generally at additional cost.

INSTALLING A-FIXED SYSTEM

Mounting the Dish

Dishes can be mounted in a variety of ways, depending upon the individual site. The easiest and most commonly used system, is to mount the dish directly on to a pole cemented into the ground.

The pole should be kept as low as possible, to make maintenance or future upgrades relatively convenient.

Dishes can also be wall mounted, providing the mount and the wall have sufficient strength. Wall mounts should be certified by a structural engineer for the category corresponding to predicted wind velocity for the site. Maximum bonding to brick and block walls is achieved using chemical anchors. For wall mounted dishes below 2.3 metres in diameter, 16mm studs should be used, whilst a 3m wall mount requires 20mm studs. A 3.7m wall mount requires 30 mm studs. These are available in galvanised or stainless steel.

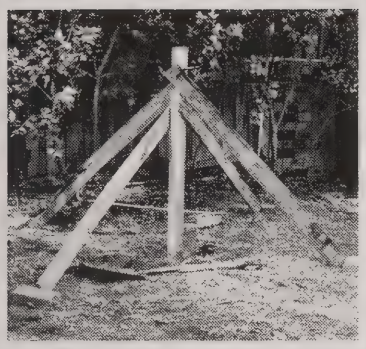
Wall mounted C band dish

It is important that the mounting pole for the dish is installed correctly. This means that it must be concreted into the ground to that it is perfectly vertical.

This can easily be checked using a simple "bubble" type spirit level. It is important that the vertical alignment is checked at two positions 90 degrees apart, around the circumference of the post.

It is often wise to brace the post in the vertical position whilst the concrete cures over several days.

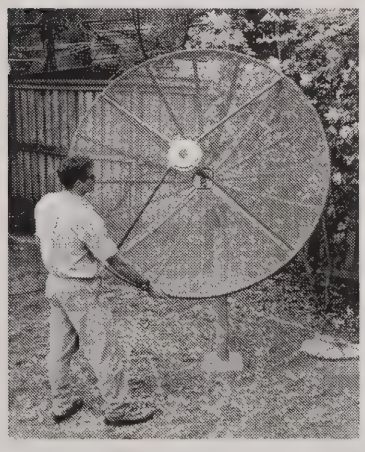
Installation-Fixed dish C band



The mounting post must be vertical

It is good engineering practice to bury the same amount of pipe in the ground, as is exposed above ground. Where this is not possible, enlarge the hole in the ground and fill with bricks or other rubble, before adding extra concrete. The aim of this exercise is to produce a larger below ground mass, to help anchor the post into the ground. In any case, ensure that the length of pipe exposed above ground is equal to half the dish diameter plus 100mm or so.

This ensures that the dish can be tilted down to zero degrees or elevation without contacting the ground.



Dish assembly

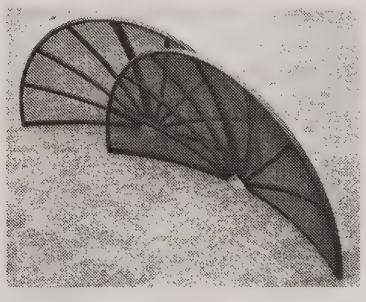
Most 2.3m and 3m dishes utilise 4 or 8 pre-assembled panels. These are the 3 recommended steps in dish assembly:

1) Reflector assembly
2) Placing the mount on the pole
3) Lifting the reflector onto the mount.

Reflector assembly

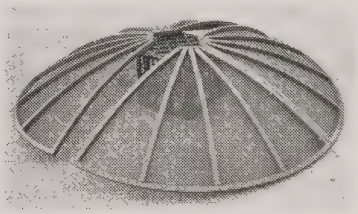
The reflector should be assembled face down on a flat surface. To do this without causing undue stress on the panels, we suggest the use of an inverted plastic garbage bin, located at what will become the centre of the dish. If assembling the dish on a concrete floor, it will be an advantage to cover the floor with a tarpaulin or cardboard sheeting, to prevent scratching the reflector rim.

Take 2 panels and bolt them together, firstly inserting the outermost bolts (those closest to the outer rim), then the innermost bolts. A flat washer should be used under both the bolt head, and the nut. Do the bolts up finger tight.



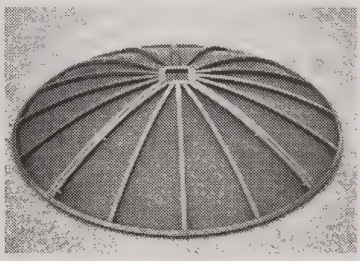
2 quadrants make half a dish; two halves make a whole dish!

Having bolted two panels together, place the apex of the first dish "half" on the garbage bin for support. When both halves are assembled and are supported by the garbage bin at the centre, mate and bolt them together. Even when the bolts are all finger tight, the reflector will assume a parabola.



Support panels prior to assembly

Using two correctly sized ring spanners, begin the bolt tightening process by working from the outermost to the innermost bolts in a clockwise direction. Tighten each bolt only to the stage where the ribs are compressed together without distortion.



Bolt both halves together face down, and sequentially tighten

By the time all outer bolts have been tightened, the parabola will have enough strength to support body weight (on the dual ribs) to enable access the innermost bolts. DO NOT

use a shifting spanner. Because of the size of the head, there is a danger of permanent mesh damage if the spanner head is accidentally pushed against the mesh. When the reflector is assembled and all bolts are tightened and with the co-operation of another person, flip the reflector over so that it points skyward.

Fixing the feed struts

The next step is to bolt the feedhorn support arms to the scalar ring (part of the feedhorn). The scalar ring is supplied with special matching bolts (scalar ring is tapped--no nuts are required). Sequentially bolt each of the 4 feed arms to the scalar ring, using the garbage can to support the weight of the scalar ring. Use the end of the feed arm having the elongated slot, as this slot allows precise

Bolt the feed struts to the feedhorn

adjustment of the focal length. The finished assembly will comprise the scalar rings with 4 feed arms attached, and spaced at 90 degrees apart. The bolts should be tightened to ensure the feed arms cannot swing around the scalar rings. As the scalar rings are aluminium, care should be taken to ensure these bolts are not over tightened.

Fixing the feed assembly to the reflector

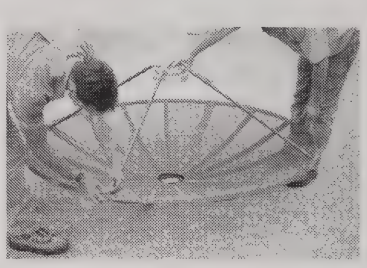
The aim of this procedure is to bolt the scalar ring and feed arms assembly to the reflector. This adds strength to the reflector prior to lifting it onto the dish mount. Ideally 3 persons are required.

Locate the 4 sets of bolts, nuts and washers that are used to secure the feed arms to the reflector. Place each of your 2 assistants at separate mounting points on the reflector, and equip them with one bolt, one nut and 2 washers.

The third person should then pick up the feed arm/scalar ring assembly and lift it over the edge of the inverted reflector, positioning the arms so that the 2 assistants can grab a feed arm each without possibility of the arms penetrating the reflector mesh.

Each assistant then inserts a bolt (with washer under the head) through the feed arm and into the reflector rib, attaching the other flat washer and nut on the underside of the reflector.

Once 2 bolts are in place, it is easy to fit the other two feed arm bolts without possibility of damage. Tighten the feed arm bolts, ensuring the feed arms are still spaced at 90 degree intervals around the scalar ring.



Carefully secure the struts ensuring the mesh is not damaged.

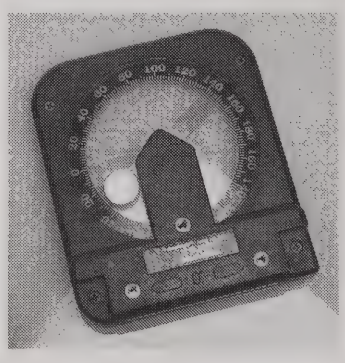
On most feedhorns there are 2 access screws used to secure the LNBF barrel to the scalar ring assembly. It is best to ensure the access holes for these screws face the ground, as feedhorn adjustment is much easier.

Dish alignment

There are 4 critical parameters, which must be accurately set, in order to align the dish with the desired satellite. Dish elevation, azimuth, focal point and LNB polarity.

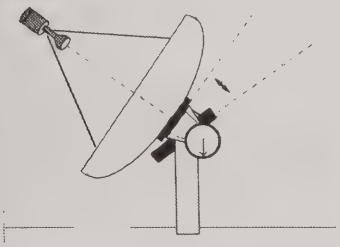
Az/El mounts

For Az/El and polar mounted dishes, the easiest way to correctly point the dish, is to set the elevation first.



Analogue inclinometer

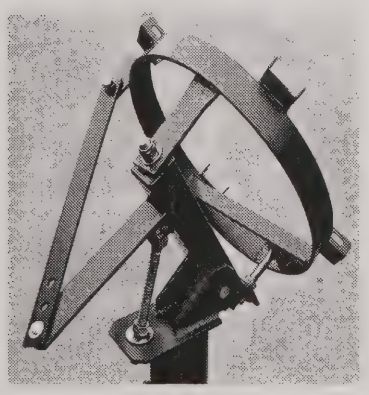
This can be done with an inclinometer, placed on the back of the reflector, or on the rim of the dish mount prior to lifting it onto the pole.



Magnetic base inclinometer or "angle meter"

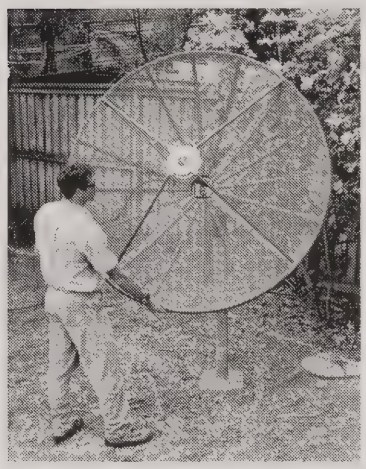
Dishes ordered without an actuator are generally supplied with an azimuth bar and hardware to allow the bar to be bolted between the mount ring and the mount as can be seen from the following photo.

This ensures that the reflector is held rigidly in position. The azimuth can then be adjusted by simply spinning the dish on the mounting post.



Mount showing azimuth bar

Once the elevation is set, the assembled dish can be rotated on the pole until a signal is observed.



Rotate the dish on the pole until a signal is observed.

MOTORISED SYSTEMS

Polar mounts

There is a detailed procedure for the correct set up of polar mounted dishes. This procedure ensures that the mount geometry is set so that the dish correctly tracks the geostationary arc and is capable of receiving all visible satellites.

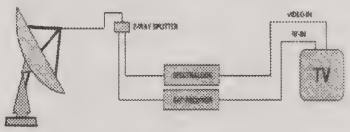
As the geometry of the dish is critical, most installers use a digital inclinometer, capable of resolving and displaying elevation and declination values to one tenth of a degree.

Also, some method of observing the satellite spectrum is required, so that satellites can be identified and signals peaked.

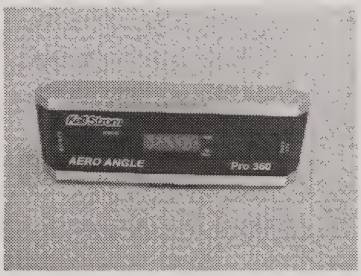
Fortunately there is a relatively inexpensive "spectral display adaptor" called the "Spectralook" capable of displaying the entire spectrum on a standard video monitor.

Display of satellite spectrum

Both this and the digital inclinometer are essential for the installation of a motorised system.



Connection of spectral display



Digital inclinometer with 0.1 degree accuracy.

Modern instruments have eliminated the necessity to base polar mount settings on locating True North.

However for the information of those without such instruments, the procedure is described here.

Finding True North is easiest and most accurately done mathematically, by determining the midpoint of the day on which the dish is to be aligned. The mid point is half the time interval between "first light" and

"last light" for a particular day. This value is different for every day of the year.

The times for first and last light can be obtained from an astronomical observatory or the meteorological office at any airport. Some time correction is necessary depending upon the location, and this correction can be obtained from the same sources.

At the precise mid-point of the day, the shadow cast by a vertical rod corresponds to True North. The shadow line can be marked on the ground or rooftop for reference.

The value of dish elevation required at True North to ensure correct tracking of the polar arc is derived by subtracting the site latitude from 90 degrees.

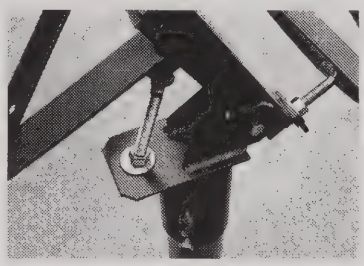
In the case of Sydney, latitude 34 degrees south, this equates to 90-34= 56 degrees.

This adjustment must be carried out with the declination adjustment set to zero, i.e. the reflector is parallel to the mount.

This polar mount adjustment, called declination, is the angle between the reflector and the mount. The value of declination varies with site latitude, and introduces tracking compensation for the apparent flattening of the

Geostationary arc when viewed from sites with extreme southerly (for our part of the world) latitude.

The declination is set in the Southern Hemisphere so that the reflector is effectively tilted forward slightly from the mount.



LH adjustment is elevation, RH adjustment is declination

Modern method

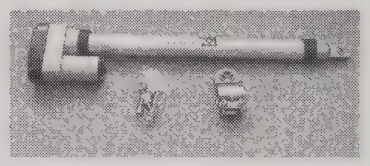
A GPS receiver can be used to provide latitude and longitude values for any location, and dish pointing software and a notebook computer enable the necessary pointing calculations to be performed on site. In the absence of any of this equipment, most satellite dealers can provide this information.

The following example shows polar mount settings for Sydney, NSW, using Satmaster Pro dish printing software.

As can be seen from the print out, the polar axis, i.e. the elevation of the dish mount, must be set to 55.43 degrees. The reflector elevation, called in this example the " modified apex elevation", is 50.57 degrees. The difference between the 2 values is the declination (4.86 degrees). Declination ensures the dish tracks in an arc, rather than a straight line (the horizon is curved, not flat!)

Procedure-detailed

Fit the actuator to the dish. For locations where most satellites are west of north, fit the actuator to the western side of the dish mount (this is the case in the eastern states of Australia).



Actuator with hardware kit, mounting collar and gasket

With the actuator fully retracted, fit the collar as close to the end of the outer tube as possible, leaving sufficient room for the waterproofing gasket.

Secure the collar bolt to the mount, and the eye bolt to the reflector. In some dishes, spacers are required to ensure the diameter of the actuator shaft doe not foul the mount. Specific actuator instructions show this.

Apply DC voltage (12 - 36 V is OK) to the motor, and align the dish and mount. This normally involves extending the actuator shaft approximately half the total available length.

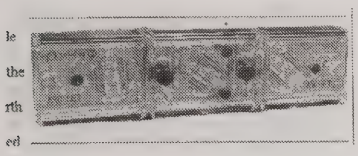
1) With the reflector and mount aligned at right angles, set the mount elevation.
2) Set the reflector elevation (subtract declination angle from mount elevation).
3) Observing the elevation value for

one of the most western visible satellites (we will use Asiasat 2 for this example), move the dish to the west, carefully monitoring the mount elevation, until the calculated elevation for the site is achieved.

4) Whilst observing the satellite spectrum on a spectrum analyser, rotate the entire dish assembly on the mounting post until the signal can be seen.
5) Tighten the mount to the pole and run the actuator across the full range of travel.

   All visible satellites should be observed.

For those who find this method cumbersome, there exists a simple instrument that can be used to align a polar mount.



Arc Set

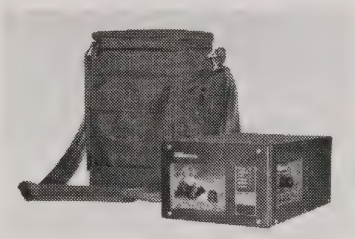
Called an "Arc Set" this device comprises an assembly of three bubble levels. Whilst not approaching the level of accuracy of the digital inclinometer, positive results are obtainable.

These 3 bubble levels allow an installer to correctly set dish mount zenith, declination and elevation, based on site data. Units are preset for a specific area at the factory.

By using dish pointing co-ordinates derived from a pointing program, the dish azimuth can be aligned to roughly the correct position.

By far the easiest way to set up a dish, is to have all the equipment i.e. receiver and TV set or video monitor, satellite meter or spectrum analyser, at the dish. This way, signals can be directly observed as the dish is moved. This is far preferable to any remote monitoring system.

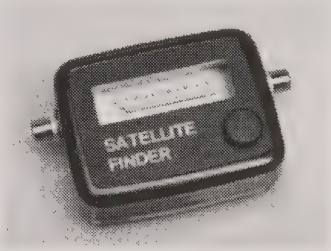
For most accurate results a satellite meter should be used. A unit for professional installers can cost from $2200 to $8000. Some meters incorporate a spectrum analyser, and Bit Error measuring system, particularly useful when aligning a satellite system to receive digital signals.



Digital satellite meter/receiver

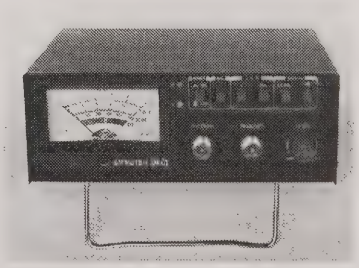
In the case of digital reception, a spectrum analyser is required for optimum adjustments to be made. As most broadcasters are moving from analogue to digital format, fewer satellites are carrying analogue signals that can be used for dish alignment.

For the DIY enthusiast a "satellite finder" is available for less than $100. Whilst not a scientific instrument, this relative power meter can be used to peak dish alignment, focal length and LNB polarity.



Economical "Satfinder"

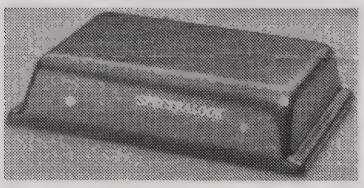
Located mid range (for about $400) is a NiCad battery powered satellite meter which is also capable of simple DC voltage and current diagnostics. The meter can indicate what DC voltage is being fed up the coaxial cable by the receiver and can measure the total LNB power from 900-2000 MHz being fed into the receiver.



Midrange signal meter

If the budget allows, a spectral display can be purchased for less than $400 which will perform all measurements required for dish alignment. The unit is used in conjunction with a

satellite receiver, which provides power to the LNB and controls the polarity selection.

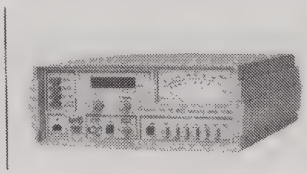


Spectralook spectral display adaptor

The adaptor allows the entire satellite spectrum to be displayed on a video monitor, allowing individual transponders to be identified, and is easily integrated into the receiving system, using a two way splitter.

Spectral display showing individual transponders

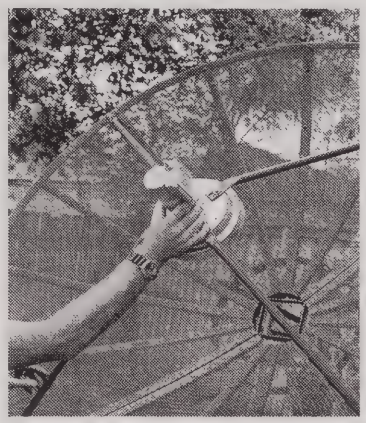
Economically priced digital meters also exist for around $3000, some future models will even contain a digital receiver.



Up market analogue meter

Peaking the dish

After first peaking dish elevation, azimuth and focal length, LNB polarity should be optimised. This is most accurately done by rotating the LNB position for the minimum level of signals having the opposite polarity, rather than peaking the LNB position for the desired signal.



Rotate the LNBF for signal peak

For a single polarity LNB (where the DC feed voltage is 18v) this means rotating the LNB for minimum meter response. For a dual polarity LNB, this means rotating the LNB for minimum meter response when the DC voltage is switched to the receiving probe for signals opposite in polarity to those required.

These adjustments require a satellite meter with adjustable frequency control.

Convention dictates 14v for vertically polarised signals, the minimum meter response is achieved when 18v is applied to the LNB. This procedure ensures maximum cross polarisation isolation.

The connection between the satellite receiving dish, LNB and feedhorn, which are all located outside, and the receiver is made via a length of RG-6/U coaxial cable. This cable carries DC voltage (18 volts maximum) to the LNB in one direction, and signal from the LNB to the receiver, in the other direction.

Even when the dish is not pointed at a satellite, a certain amount of noise or "snow" can be observed on the screen of the video monitor or TV set being used. Disconnecting the cable at the back of the satellite receiver, and noting the corresponding drop in "snow" on the screen is a simple method of verifying the integrity of the cable.

If a drop in the noise level is observed, this means the cable and the LNB are working correctly.

Provided the receiver is tuned to an operational satellite channel, acquisition of a signal is simply a matter of pointing the dish correctly.

Most modern satellite receivers have an RF test signal as part of the modulated output facility. Normally such a modulator has a UHF output and the test signal can be switched on to verify correct TV channel tuning.

Inclined Orbit Satellites

Inclined Orbit Satellites

Somewhat more of a challenge is the set up of a dish to receive signals from a satellite in an inclined orbit. Some ageing satellites, kept in orbit due to the backlog of launch bookings for new satellites, have been deliberately placed into an inclined orbit, to prolong their useful life. Fortunately, the number of inclined orbit satellites has decreased dramatically since 2000.

In this situation, a certain amount of station keeping tolerance is acceptable to ground stations. By accepting the resultant effects of gravitational pull of the Sun and the Moon, the radiation force of sunlight, and the pull of the gravitational field of earth, and allowing the satellite to drift within a target "box" or window in space, a significant amount of station keeping fuel can be conserved.

There does exist a patented manoeuvre, called the "Comsat Manoeuvre", which cleverly conserves station keeping fuel. Part of the patent reads. "a conventional satellite uses an average of 37 pounds of station keeping fuel for each year of design life, approximately 34 pounds of fuel is used for North/South correction, whilst only 2 pounds is used for East/West correction, and one pound for attitude control".

So it is obvious that any kind of manoeuvre that can minimise the amount of fuel used in North/South station keeping can prolong the life of the satellite.

Generally, satellites have been placed in an inclined orbit deliberately, either due to low station keeping fuel reserves, or in the case of early Russian satellites, because such an orbit takes the satellite over populated landmasses, rather than ocean for most of a 24 hour period.

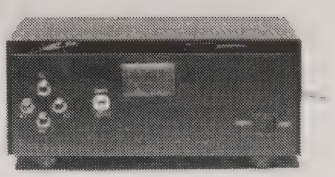
Commercial PWM tracker

Whatever the reason, acquiring, then tracking an inclined orbit satellite requires more skill than a fixed satellite.

If 24 hour reception of such a satellite is required, the dish mount must be fitted with bearings or bushes in both axes, to ensure that the constant movement of the mount does not cause it to wear.

A standard polar mount without bushes (particularly in the elevation axis) is not suitable. Typically, the elevation pivot is formed by a threaded bolt, which acts like a file during tracking operation, quickly wearing out one side of the mount !!

A satellite tracker must also be incorporated into the receiving system if it is to use AGC to follow the satellite signal.



Homebuilt dual axis auto-tracker

The most logical way to predict the azimuth and elevation of an inclined orbit satellite, is to obtain pre-calculated co-ordinates. This kind of information is normally available from a satellite equipment dealer, and often from satellite computer bulletin boards.

Because, the orbit of an inclined satellite is controlled by an earth station, the orbital or Keplerian elements are available from NORAD, the US government agency charged with monitoring all objects in space. Most satellite oriented internet sites keep these elements on file, and constantly updated.

By "plugging in" these orbital elements into a computer tracking program, a table can be produced showing where an inclined orbit satellite is, at any time of the day or night.

This table also shows the time at which the satellite will be located with zero degrees variance from the nominal orbital location.

Once the satellite is located and a signal acquired, the system tracker must be installed. Various trackers are available, from the simplest single satellite tracker, to more complex trackers incorporating predictive memory, and

complex microprocessor circuitry with sufficient memory for many satellites.

The single satellite tracker uses a fixed time interval to sample received satellite signal strength. The unit has an inbuilt tuner, set to the desired input frequency. Every fifteen minutes or so, the internal micro-processor drives each motor (one per axis) in each direction for 950mS or so.

As the dish moves, the received signal strength will either increase or decrease, instructing the motor control circuit to either continue in the same direction or to reverse the motor direction.

For this system to work well, the dish must be well balanced so that travel in an upward direction for a fixed time interval, equals distance travelled in a downward direction for the same time interval.

Dish mounts should employ bearings or at least bushes in the elevation axis, and often must use a counterweight for correct balance.

The multi satellite tracker requires an external AGC voltage, and uses a PWM (pulse width modulation) motor drive circuit to ensure minute changes in actuator position, whilst peaking the dish. This system has the advantage of rarely degrading the received signal to any large extent during auto-track operations.

Some sophisticated receiver/positioners incorporate an "event timer", which can be programmed to move the dish in a specified direction at a specified time. This results in far less wear on the dish movement system. Most of these receiver/positioner models were the last production type in the analogue format, and are incapable of receiving DVB signals. Never the less they can still be used as a "beacon" receiver to track inclined orbit satellites carrying digital signals.

Multiple Satellite System

When proposing to install a system for receiving multiple satellites, attention should be paid to the weakest satellite available, and what dish size is required for good reception of that satellite.

The location of the dish must be such that is has a clear view from the (calculated) most western to most eastern azimuth. Generally, this means a clear view from the western horizon to the east. As there is no satellite having a footprint over Australia located further east than 183 degrees east longitude at present, although that could change in time. At present it is safe to use 183 degrees east longitude when calculating the most eastern azimuth.

For dishes located on the east coast, the most western satellite visible is the Apstar 2R satellite located at 76.5 degrees east. The required elevation for this satellite is around 4 degrees. Dishes located further west will have a marginally higher "look" angle.

Receiving systems for multiple satellites, where satellites are located low on the horizon, should use a H-H mount, or a motorised Az/El mount instead of a standard polar mount. Such a system should also use a dish controller, capable of controlling actuators in both axes. Some receivers have this capability built in.

Having considered the appropriate dish size, and location, some regard should be given to the polarisation used by all available satellite transponders.

For C band satellites, a dual polarity LNBF will serve most needs. However, where linear and circularly polarised signals must be received, a feedhorn capable of being remotely adjusted for linear (vertical and horizontal) as well as circular (RHCP and LHCP) should be chosen. Such a feedhorn uses a mutually coupled, movable probe, to allow adjustment to the correct satellite axis.

Multipolarity feedhorn

There is a performance trade-off for the convenience of having access to both linear and circularly polarised signals.

In some cases, a dedicated feedhorn for circularly polarised signals may be necessary, as the mutual probe arrangement can cause poor cross polarisation isolation.

In our part of the world, K band signals use only linear polarisation.

As we have many available satellites utilising linear polarisation, some regard to polarisation offset is necessary. If the receiving site was located directly below the satellite, there would be no polarisation offset. Traditionally, the vertical polarisation reference is assumed to be perpendicular to the equator.

The angular difference between the polarisation plane of the satellite, and that of the receive site, varies with site latitude and the longitudinal difference between the satellite and site. However, many broadcasters follow the practice of tilting the satellite polarisation (particularly with spot beams), so that the polarisation plane at the centre of the footprint coincides with the local vertical reference.

This is why it is important to use a feedhorn capable of polarisation adjustment, even for reception of satellites employing linear polarisation.

Unfortunately there does not exist a commercial product capable high performance polarity adjustment.

The ultimate adjustable feedhorn would use a servo motor to rotate the entire LNB, orienting the pickup probes with the polar axis of the satellite, and eliminating the mutually coupled probe technique.

In reality, the majority of multi-satellite installations utilise a dual polarity LNBF where the polar axis is set to a compromise position, affording acceptable but not optimum reception.

If dual band reception is required, consideration should be given to the difficulty experienced in pointing a large dish (with narrow beamwidth) at a K band source, and to the inefficiency of mesh dishes at K band, which typically drops to around thirty percent. Also, there are some feed inefficiencies which will be introduced when using a dual band feedhorn.

Considering the limited number of sources of K band signals available, it is far preferable to use a second, dedicated dish for K band reception. In such an instance, a dual input receiver is required.

International Video Standards

It is common knowledge that most countries around the world use either the NTSC, PAL or SECAM video standard. On international satellites it is not uncommon for a combination of standards to be used. In the Pacific, Panamsat is a typical example.

The differences between the 3 major video systems are not as clear cut as they might initially seem, and it is true to say that all systems are a compromise between complexity and monochrome compatibility. All TV receivers require a field timing reference signal, and initially this reference was derived from the AC mains.

As there are two main power frequencies in use around the world, the three major systems are based on either 25 frames per second (50Hz), or 30 frames per second (60Hz). This is the biggest incompatibility between standards, and the most difficult to resolve.

The majority of 60Hz based countries use a system called NTSC, developed in the USA in 1953 by the National Television Standards Committee. Because of problems of hue variance (caused by changes in the colour sub carrier phase) the NTSC system is sometimes referred to as the Never Twice the Same Colour system. Because NTSC uses a higher frame rate (30 frames per second) than PAL, it has reduced video flicker, however as the gamma ratio for NTSC is set to 2.2, NTSC cannot produce the high level of contrast achievable with the PAL system.

International Video Standards

A modification of the NTSC system, devised by German engineers to overcome the hue problem, called the PAL (phase alternating line) system was introduced in most 50Hz countries.

Known by some as the Pictures At Last system, the main difference between NTSC and PAL is the colour sub carrier phase reversal on each alternate line. The frequency of the colour sub carrier is also different to that used in the NTSC system.

The main advantages of the PAL system are: the greater picture detail, (625 scan lines compared with 525 for NTSC), a higher gamma ratio (2.8), for greater picture contrast, stable hue due to the reversal of the sub carrier phase on alternate lines (any phase error on the subsequent line), and wider luminance signal bandwidth due to the higher sub carrier frequency of 4.43 MHz.

PAL is the most widely adopted system in the 50Hz countries.

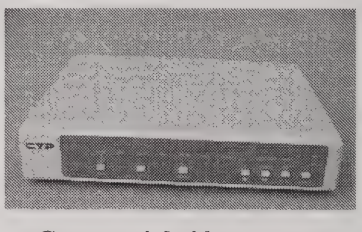
The French designed a system of their own known as SECAM (SEquential Couleur Avec Memoire). Known by some as System Essentially Contrary to American Method, the SECAM system is said to have been designed to protect the French domestic manufacturing industry. The SECAM system has similar advantages over NTSC, but has the primary disadvantage that the FM sub carrier used causes patterning effects even on non coloured objects. Also, there are a wide number of SECAM variants which are incompatible. French SECAM uses an FM sub carrier, whilst Middle Eastern SECAM uses an AM sub carrier.

The table to right shows the video standards used in the South Pacific and adjacent countries. Of course it is possible to view all international TV standard signals on a PAL monitor in black and white. However, if colour reception is required, either a multi-standard monitor or a multi standard converter is required.

Multi-system video converters range from simple "sub carrier" types, which merely change the frequency of the colour burst signal, to more complex digital converters containing up to 16Mb of field memory, comb filtering, and which perform frame store and timebase correction functions.

As technology has improved, the price of digital converters has dropped dramatically, to one tenth of the cost of such a device in 1990. Now, digital converters are available for less than $700, and can be used to view and record all video standards on PAL equipment.

This is by far preferable to the purchase of a multi-standard VCR and monitor. Once converted to PAL, satellite signals can be distributed using existing MATV equipment.



Commercial video systems converter

International video standards

Australia	**PAL**
Brunei	**PAL**
Burma	**NTSC**
China	**PAL**
Fiji	**PAL**
France	**SECAM**
Germany	**PAL**
Hawaii	**NTSC**
Hong Kong	**PAL**
India	**PAL**
Indonesia	**PAL**
Italy	**PAL**
Japan	**NTSC**
Korea(N)	**SECAM**
Korea(S)	**NTSC**
Malaysia	**PAL**
Micronesia	**NTSC**
New Zealand	**PAL**
PNG	**PAL**
Philippines	**NTSC**
Portugal	**PAL**
Russia	**SECAM**
Samoa(E)	**NTSC**
Samoa(W)	**SECAM**
Singapore	**PAL**
Sri Lanka	**PAL**
Tahiti	**SECAM**
Taiwan	**NTSC**
Thailand	**PAL**
USA	**NTSC**
Vanuatu	**PAL**
Vietnam	**NTSC**

WIRING THE SYSTEM

External Wiring

After the site survey has been completed, and the dish located so that all desired satellites can be received, the electronics of the system must be wired.

Cables connecting the dish motors, LNB, and feedhorn must be routed in such a way that they cannot be damaged by animals or humans. In most installations, cables running between the dish and the receiver are buried underground in PVC conduit. Burying the conduit 200mm or so below the surface minimises the possibility of cable damage.

Where conduit is used above ground it must "UV stabilised" to prevent deterioration caused by sunlight.

Conduit entry and exit points should be made 500mm or so above the surface, using two 90 degree elbows, so that no surface runoff can enter the conduit in the event of rain. The size of conduit used should be twice the collective diameter of the cable "bunch", to allow cables to be easily pulled through conduit sections prior to sealing and subsequent burial.

Conduit installation

If future equipment upgrades are contemplated, such as dual band operation or dual axis dish motorisation, the additional cables to be used should be installed with the initial system wiring. It is almost impossible to pull extra cable through buried conduit.

Generally a suitable trench can be dug with common garden tools. However for long trenches, an automated trench digger, available from most equipment hire companies can be employed.

Where line amplifiers must be used it is always wise to externally mark the conduit with the position of the line amplifier should maintenance be required some time in the future.

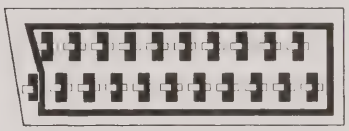
It is wise to verify cable integrity by connecting the system components with all external cables running on top of the ground. This ensures any cable faults are located prior to burial.

Internal Wiring

Most satellite receivers use either RCA sockets or SCART connectors to allow access to video, baseband and audio (left and right) signals. In addition most receivers have some means of accepting an external video and audio source and routing it through the receiver so that it appears at the A/V and RF output of the receiver.

A SCART socket is the most convenient way of providing these inputs and output signals. It also allows signals that have been processed by an external decoder (or video standards converter) to be switched to the satellite receiver modulator.

SCART is a European audio-video connection system developed by the French company Peritel, and stands for "Syndicat Francais des Constructeurs d'Appareils Radio et Television".



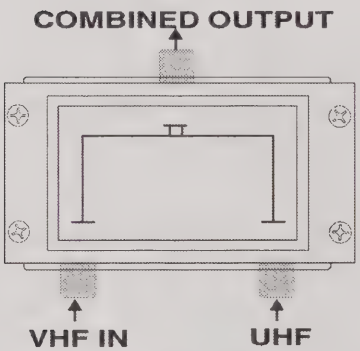
SCART socket. Table shows pinout

Pin 1	Audio out R
Pin 2	Audio in R
Pin 3	Audio out L
Pin 4	Audio ground
Pin 5	Blue ground
Pin 6	Audio in L
Pin 7	Blue
Pin 8	Function sw
Pin 9	Green ground
Pin 10	Comm data 1
Pin 11	Green
Pin 12	Comm data 2
Pin 13	Red/Chroma gnd
Pin 14	Comm data gnd
Pin 15	Red/Chroma
Pin 16	Blanking
Pin 17	Video ground
Pin 18	Blanking ground
Pin 19	Video output
Pin 20	Video input
Pin 21	Common ground

The 21 pin connector allows bi-directional connection of audio and composite video signals, uni-directional RGB video, plus control signals for TV/VCR interaction. Pins are marked on the connector.

In some installations the RF output of the satellite receiver will need to be combined with the RF output of other items such as VCR, Laserdisc DVD player etc. before connection to a TV set.

RF combiners allow the mixing of signals from multiple VHF and UHF sources into single output.



Typical combiner connections

Where the best possible video and audio fidelity from the satellite receiver is desired, direct video and audio connections should be made. The re-modulation process of an RF modulator does slightly degrade performance.

With the introduction of digital terrestrial television, the use of quad shielded coaxial cable has become most important. The ingress of digital terrestrial signals into cable systems utilising inferior coaxial cable will become a huge problem in the next few years, as these services are rolled out around the country.

The interfering effect of these signals is generally manifested in noticeable cross hatching, noise and "fuzzy' audio.

Where signal distribution is performed with discrete composite video and line level audio outputs, a distribution amplifier should be used to ensure the correct output levels and impedance is preserved.

Maintenance

Most modern electronic items, once correctly installed, are extremely reliable. A home satellite TV system is no exception.

Apart for regular dish inspection to ensure adequate bush or bearing lubrication, re-application of rust and corrosion inhibitor and visual inspection of the dish surface, no maintenance is required.

Actuators should be inspected to ensure that moisture drains away from the motor housing. It is for this reason that the motor should always be positioned above the gearbox housing at the end of the drive shaft.

If surface rust appears on the steel dish mount, anti rust paint or rust converter should be applied to limit the degradation.

In locations subject to salt water vapours, the use of "fish oil" on all exposed steel parts can extend the life of a dish by many years. Deodorised fish oil is available in aerosol applicators,

The dish should be kept clear of obstructions as the collection of leaves and other debris may reduce the reflector efficiency, especially when wet.

In extreme cases where leaf litter degrades into compost, new growth vegetation can sprout, dramatically reducing dish efficiency.

In addition the growth of trees adjacent to the dish should be monitored. If foliage encroaches the dish effective surface area, and hence the gain, will be reduced.

Indoor equipment should be operated in a well ventilated location to prevent overheating, by allowing sufficient airflow around external casing. This is particularly true of integrated receiver/positioners, where heat dissipation is somewhat higher than normal.

Some installations housing a significant amount of heat generating equipment warrant the use of a small air-conditioner.

In commercial applications there is a significant advantage in operating satellite receiving equipment from a UPS (Un-interruptable Power Supply). If the power fails, or power transients are fed down the power line, the UPS continues to provide smoothed AC power to the equipment, eliminating the possibility of receiver power supply damage.

Some satellite receivers have an AC input range of 90-240V. In Australia the AC mains voltage can exceed 260V in places, stressing the power supply.

In such cases it may be prudent to operate equipment from either an appropriately rated 240-110V or 260-240V step down transformer.

If a fault does occur in a satellite receiving system, it can normally be traced to a recent "human" occurrence involving spilt drinks, inadvertent lawn mowing accidents, power surges etc.

Solar Outages

Also known as Sun fade, Sun transit or Sun outage.

There are two occasions each year, when home satellite reception is affected by the sun. These periods occur after the vernal equinox and before the autumnal equinox. At these times day and night are approximately the same duration and the Sun crosses the equatorial plane, in a trajectory that places it directly behind the geostationary arc.

In the Southern Hemisphere this means we will experience the problem in March and September each year.

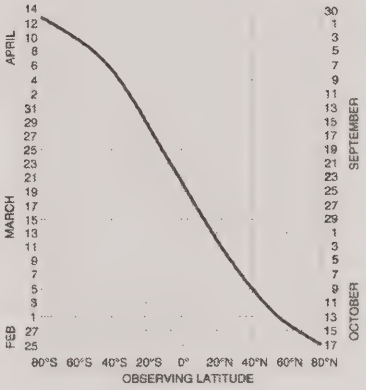
At these times, and for a few days before and after the equinoxes, the sun is in alignment with both the satellite and the earth station. The Sun appears as a huge noise source, increasing the antenna noise temperature to the order of 25000 degrees K. At 4 GHz, the solar radio emission from the sun is up to 20 dB in excess of the satellite TV signal being received. In most cases this totally obliterates the satellite signal for a short period.

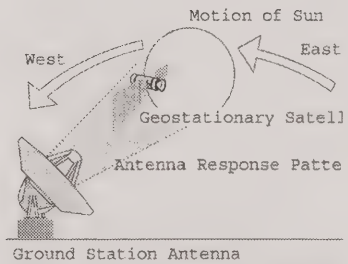
Solar interference can take place up to 21 days before and after both equinoxes, depending upon station latitude. The duration of the Solar Outage depends upon the beamwidth of the field of view of the receiving antenna, the apparent radius of the Sun as seen from earth, the RF energy emitted by the Sun, the gain and Eb/No of the receiving station.

Duration of the interference is usually 15 minutes or so, based on an antenna beamwidth of 2 degrees, and can last up to 30 minutes on smaller dishes having a wider beamwidth.

During periods of solar interference, care must be taken to ensure that satellite tracking equipment is placed in manual mode, at the particular time of interference, so that the tracker does not lock onto the interfering noise. If this were allowed to happen, the dish would track the sun as it appeared to move across the sky, instead of the satellite.

The following graph allows the user to predict the time and date of solar equinoxes, for a particular location.





Solar outages affect satellite reception

Glossary of Terms

Actuator - External motor and gearbox driving a screw mechanism to produce lateral movement. Used to move dish in azimuth, elevation or both axes.

AFC - Abbreviation for automatic frequency control. An electronic circuit ensuring that a receiver stays locked onto a signal, once acquired, compensating for frequency drift.

AGC - Abbreviation for automatic gain control. An Electronic circuit which compensates for variation in signal levels, to provide a constant input level.

Algorithm - A set of predetermined steps for solving a mathematical problem.

Alignment - A process of fine tuning a circuit or component to maximise performance.

AM - Abbreviation for amplitude modulation.

Amplifier - A circuit for increasing the level of signal voltage or power.

Analogue - A method by which a variable is represented by continuous movement.

ANIK - Eskimo word meaning "brother".

A.O.S-acquisition of signal.

Antenna - A device for either receiving or transmitting a signal.

Aperture - The total reflective area of a dish.

Apogee - The point in an elliptical orbit that is furthest from Earth.

Apogee Kick Motor - A small engine, operating on pressurised gas, affixed to a satellite and normally fired to propel the satellite from a low earth to geostationary orbit.

Attenuation - Signal reduction.

Audio sub carrier - The frequency onto which audio information from a satellite transponder is superimposed. Generally within the range 5.5-9MHz.

Az/El mount - A dish mount having two adjustments, azimuth and elevation.

Azimuth - The angular displacement in the horizontal axis. In practice this means the east-west movement of a dish.

Bandwidth - The range of frequencies passing through a transmission medium.

Band pass filter - a filter which allows only signals contained within a certain band of frequencies to pass.

Baseband - The range of frequencies produced in a satellite receiver, after processing in the tuner. Subsequent processing of baseband signals results in both video and audio outputs. Baseband signals range from DC (zero) to 10MHz.

Bird- slang for satellite.

Bit Error Rate (BER)-

The probability of errors over the satellite link. A measurement of the performance result of the link.

Bore sight - The area of highest signal concentration of a downlink signal. Normally the centre of a satellite "footprint".

Cable TV - A method of distributing multiple channels of television down a coaxial cable, as distinct from satellite delivered TV signals.

CAM - Conditional Access Module.

Carrier to Noise ratio - The ratio of satellite signal power + noise to noise power. The C/N ratio is an indication of the efficiency of a satellite dish/LNB and Feed system.

Cassegrain antenna - A parabolic dish using a sub reflector at the focal point to reflect signals to the centre of the dish. Compared to a prime focus parabolic antenna, the cassegrain design offers improved efficiency.

C band - An internationally agreed frequency block for down linking satellite signals, covering 3.4-4.2GHz. The corresponding 6GHz uplink block of frequencies is also known as C band.

CCIR - Abbreviation for Comite Consultant International des Radio Communications. The CCIR is part of the ITU.

Circular polarisation - A type of polarisation of satellite signals, used primarily by Intelsat and Russian Gorizont spacecraft. Abbreviated to either LHCP or RHCP (left or right hand circular polarisation).

Glossary of Terms

Clarke Belt - The name given in honour of discoverer Arthur C Clarke, to the orbital belt 37,000Km in space above the equator.

Coaxial cable - A constant impedance cable used for the transmission of signals between pieces of equipment. The cable has a centre conductor separated by a dielectric material from the outer tubular shield.

Co-located - refers to 2 or more satellites in the same orbital location.

Companding - A method of dynamic range compression, used when bandwidth is limited. After transmission, the original dynamic range is restored without degradation, through an electronic expansion process.

Composite video - The complete video signal, including chrominance, luminance, and sync information.

COMSAT - Abbreviation for Communication Satellite Corporation. A corporation set up to represent US interests within INTELSAT.

Data compression - A method of transmitting data using fewer information bits without loss of intelligence. The received data is expanded to restore the original signal.

DBS - Abbreviation of Direct Broadcast Satellites.

dBw - Scientific notation meaning the number of decibels above 1 watt.

Decibel - Abbreviated to "dB" a unit of measurement used to express ratios logarithmically. A 3dB improvement represents doubling the signal power, a 10dB improvement is a tenfold increase, a 20dB improvement is a 100 fold increase.

Declination - Angle between the polar axis and reflector to ensure correct tracking of the orbital belt.

Decoder - A device which translates encoded signal information into a format that can be used by a standard receiver.

De-emphasis - One half of a system used to improve the video and audio signal to noise ratio of a signal by artificially emphasising the high frequency baseband components.

Demodulation - A process used to retrieve original information from a transmitted signal.

DES - Abbreviation for Data Encryption Standard. An encryption system utilising an algorithm described by the US National Bureau of Standards.

Dielectric - Insulating material used in coaxial cable to separate the outer shield from the centre conductor. This ensures the impedance of the cable remains constant. Dielectric material can also be used as a signal polariser in a feedhorn.

Digital - Information in discrete form, normally in binary bits, i.e. "0" or "1".

DiSEqC- (digital equipment satellite control). A packetised 22KHz signalling system.

Downlink - The path from the satellite in space, to earth.

DTH - Direct to home satellite service. Normally a high powered service, utilising K-band and requiring a small aperture dish.

DVB (digital video broadcasting)- European project to harmonise the adoption of digital video.

Eb/No- predictive tool used to measure link performance. The energy per bit to noise power density ratio.

ECM - Entitlement Control Message.

EMM - Entitlement Management Messages.

EIRP - Abbreviation for Effective Isotropic Radiated Power. A measure of the strength of a satellite signal, normally expressed in decibels above 1 watt (dBw).

Elevation - Angle made between the horizontal plane and the axis of the dish when pointed at a satellite.

Elliptical - Oval in shape (an ellipse).

Encryption - A method of manipulating a satellite signal, for the purposes of security, so that it cannot be received without decoding equipment.

Equatorial orbit - Orbit around earth above the equator.

Express - Russian name for orbital locations reserved for "Express" class satellites.

Glossary of Terms

F/D ratio - The ratio of the focal length to depth of a parabolic dish.

FEC-(Forward error correction) the number of bytes of information used to correct transmission errors compared to the total number of bytes sent.

Feedhorn - A mechanical focussing assembly, located at the entrance to the waveguide feeding signal to the LNB on a satellite dish.

Field - Electronic scanning of either odd or even lines of a television picture.

Figure of Merit - A measure of the quality of a dish performance. expressed as a ratio, G/T (gain/noise temperature).

Flat plate antenna - Satellite antenna either phased element or zone type, which appears to be flat, instead of curved.

FM - Abbreviation for frequency modulation.

FM improvement - The inherent noise reduction capacity of an FM receiving system. The maximum value approaches 39dB, when the signal is above threshold.

FM threshold - The level of input signal required to produce subjectively noise free pictures.

Focal length - The distance from the focal point to the centre of a dish.

Focal point - The point at which all signals reflected by the dish are focussed. The focal point is determined by the shape of the dish.

Footprint - The area on earth covered by a satellite signal.

Frame - The 625 lines (or 525 lines in the case of NTSC) that form a television picture.

GEO - Geostationary earth orbit.

Geostationary - A fixed position in space, relative to earth.

Geostationary Transfer Orbit - GTO, temporary elliptical orbit of a satellite, directly after launch, prior to geostationary insertion.

Gigahertz - A measure of frequency. 1GHz equals one billion hertz (cycles per second).

Gorizont - Russian for horizon.

Ground noise - Unwanted electronic noise generated by the earth.

G/T - Known as the "figure of merit", is the ratio of system gain to system noise.

GTO – geostationary transfer orbit.

HDTV - High Definition Television. A new video standard utilising 1200 scanning lines and 16:9 aspect ratio (screen format).

HEMPT - High Electron Mobility Transistor. Used in low noise amplifiers and LNB's.

Hohmann transfer orbit- see GTO

Horn - A piece of waveguide, pyramidal in shape, which allows a gradual impedance change between free air and the low impedance input of an LNB.

Hyperbole - Convex reflector used as part of a Cassegrain reflector, to reflect incoming signals from the dish surface to the feedhorn.

IC - Integrated Circuit.

IF - Intermediate Frequency. A frequency or block of frequencies produced as a result of frequency conversion.

Impedance - The sum of the resistance and the reactance of either a capacitor or and inductor.

Inclined orbit - An orbit offset from the equator.

Inclinometer - An instrument used to measure dish elevation and declination.

INTELSAT - Stands for International Telecommunications Satellite Consortium.

IRD –Integrated receiver decoder.

ITU – International Telecommunications Union.

K band - 12.25-12.75GHz for the Pacific Region (ITU region 3).

Kelvin (K) - A temperature scale where absolute zero, the temperature where all molecular activity stops =0 K. Absolute zero equals -273 degrees C.

LEO - Low earth orbit.

LNA - A term used in the early days of satellite equipment to refer to the Low Noise Amplifier section, now an integral part of a modern LNB.

Glossary of Terms

LNB - Low Noise Block Converter. The device that amplifies and converts the incoming satellite signal to the block of IF frequencies presented to the satellite receiver.

LNC - A term used in the early days of satellite equipment to refer to the combination of low noise amplifier, and frequency converter in the one package. This was a tuneable single frequency device, having an output centred around 70MHz.

Low Pass Filter (LPF.) - A filter allowing only signals below the nominal filter frequency, to pass.

Margin- The amount of signal by which the satellite link exceeds the minimum levels required for operation.

Multiplexed Analogue Components (MAC.) - A broadcast standard using analogue picture and digital audio components. B-MAC is the variant used in the Pacific.

Main lobe - The signal response of a dish corresponding to the area directly in front of the reflector.

Molniya - Russian for "flash of lightning"

Mount - The structure used to support and aim the dish. Common types are Az/El, El/Az, Polar, and Horizon to Horizon.

MPEG - A digital transmission standard devised by the Motion Picture Entertainment Group.

NTSC - US television standard utilising 525 scanning lines. Commonly known as "Never Twice the Same Colour"!

Offset antenna - Elliptical antenna, where the feedhorn assembly is offset from the reflector, to prevent aperture blockage.

Ortho mode Coupler (OMT) - Specialised feedhorn allowing two LNB's to be mounted for simultaneous reception of vertical and horizontally polarised signals.

ONC –operational navigation chart used by aviators for international navigation.

Palapa- Indonesian word for "fruit of labour".

PAL - European broadcasting system used in Australia and New Zealand, utilising 625 scanning lines.

PAM - Payload assist module.

Parabola - Geometric shape utilised by most dish makers.

Phase Locked Loop - An electronic circuit capable of locking onto and tracking frequency variations of an input signal. Used in most satellite receivers.

Polar orbit - A satellite orbit perpendicular to the equator. Satellites using this track orbit the North and South poles.

Polarisation - The plane of vibration of the electric field of a signal radiated from a satellite antenna. Signals can be transmitted using vertical, horizontal, left hand circular or right hand circular polarisation.

Polariser - A device placed in the feedhorn to change the polarity of the incoming signal to that to which the LNB probe is aligned.

Positioner - Also often known as a controller, is the indoor unit used to control the operation of an actuator motor on the satellite dish. Positioners are also often integrated into modern satellite receivers.

Prime focus antenna - Parabolic antenna where the feedhorn and LNB are placed at the focal point of the dish. Sometimes called the "centre focus " antenna.

Raduga - Russian for "rainbow".

Receiver sensitivity- Expressed in dBm, is the amount of power required by the receiver input to meet specific performance targets such as BER or C/N.

RF - Radio frequency. Any frequency falling between 100KHz and 100GHz.

SAW filter -(Surface Acoustic Wave). Sharp filter used in a satellite tuner.

SCART - Also known as the Euro or Peritel connector. A multi pin connector developed in France to allow easy interconnection between satellite receiver and external decoders.

SCPC - Single channel per carrier. A transmission system where a separate channel is allocated for the transmission of audio information.

Glossary of Terms

SECAM - French television standard.

Side lobe - Response of an antenna to satellite signals arriving at the antenna "off axis".

S/N - Signal to Noise ratio. The ratio of signal + noise to noise power, expressed in dB. The quality of audio and video signals can be described using this measurement.

Skew - A method of rotating a pickup probe coupled to the LNB so that it is in alignment with the incoming satellite signal.

Slant range- The path distance between satellite and earth station.

Slot - Slang for "orbital location".

SMATV - Satellite Master Antenna TV. The headend where satellite signals are received and subsequently transferred into an existing TV antenna/distribution system.

SNG - Satellite News Gathering Unit. Typically a mobile uplink van, capable of unlinking directly to the satellite.

Sparklies - Impulse noise caused by insufficient signal. Manifested visually as black and white dots superimposed on a satellite signal.

Spherical antenna - Spherical shaped antenna with multiple focus points, intended to receive multiple signals simultaneously.

Spill over- Satellite signal falling on locations outside the published coverage area.

Statsionar - Soviet name meaning stationary, used for orbital locations reserved for Raduga & Gorizont satellites.

Station keeping - Process performed by ground control stations, where command signals are uplinked operating pressurised gas thrusters to keep the satellite "on station".

STB (set top box)- satellite receiver, implies CA type.

Symbol Rate (SR)-

The speed at which a digital signal is sent.

Threshold - Subjectively, the minimum C/N ratio required for a satellite receiver to deliver a locked colour picture.

Transponder - A spaceborne repeater. Signals received are amplified, frequency converted, and retransmitted.

TVRO - TV receive only. A satellite system designed only to receive signals, not transmit.

Uplink - The earth to satellite segment of the satellite circuit.

Video crypt - A cut and rotate encryption system, designed for use with PAL TV signals delivered by satellite.

Vidiplex – Economical analogue compression system, allowing simultaneous transmission of 2 interfaced video signals

Waveguide - A tube of precise dimensions, used to conduct microwave signals.

WAC -(World Aeronautical Chart) navigational chart used by aviators for domestic navigation.

Zenith - Highest point.

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Satellite Data for Orbital Locations

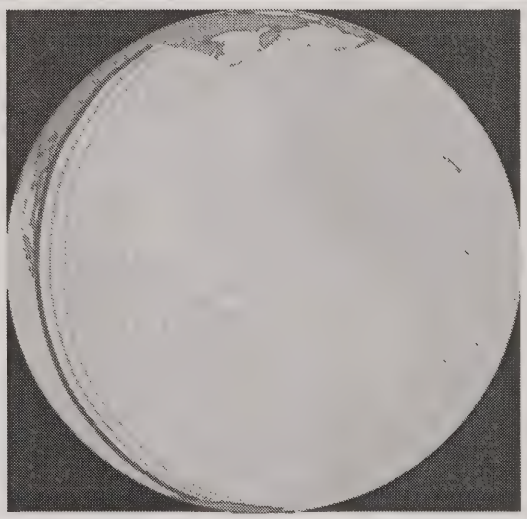
Launch Date 23/09/97
Launch Vehicle Ariane V100
Mass In Orbit 2920 Kg
Design Lifetime 15 years
Origin International
Type AS7000
Stabilisation 3 Axis
Norad # 24957

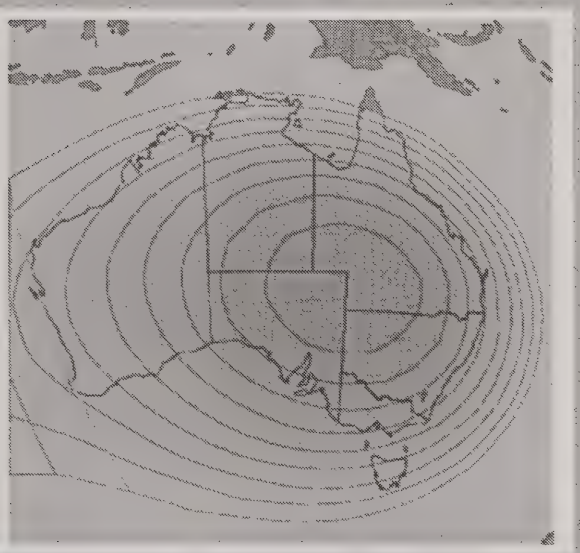
NSS-5
Located at 183 degrees E

Located 27.5W 9/97 to 12/97
Located 21.5W 1/98 to 8/02
Located 19.8W 8/02 to 10/02
Located 183E 16/12/03
Previously owned and operated by Intelsat.
Previously called NSS-803

TRANSPONDERS

C band	38
Power	7-22 Watts (zone) 27-38 Watts (global)
Bandwidth	36/72 MHz
Coverage	Asia, Australia, Oceania
Polarisation	Circular
K Band	6
Power	6 x 43 Watts
Bandwidth	72/144MHz
Coverage	N Asia, W USA
Polarisation	Linear





Footprint source: www.newskies.com

Satellite Data for Orbital Locations

Launch Date 22/10/93
Launch Vehicle Ariane V60
Mass In Orbit 1800 Kg
Design Lifetime 15 years

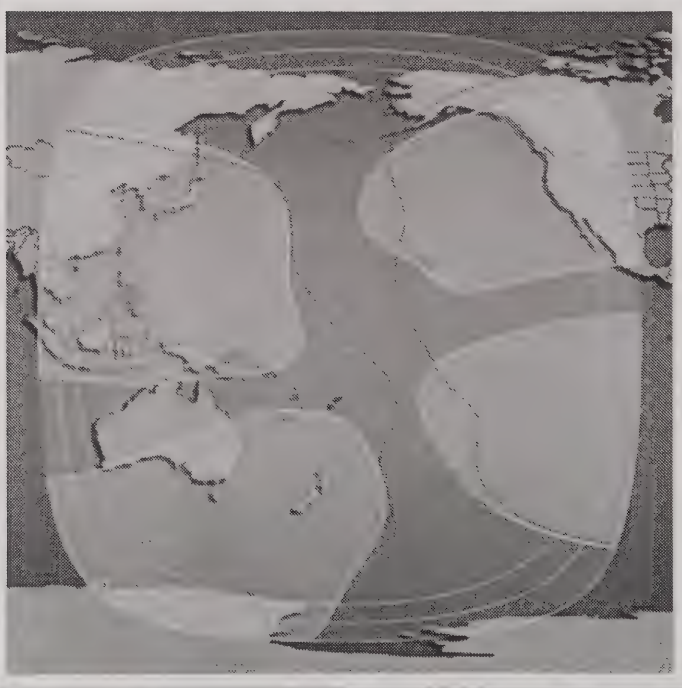
Origin International
Type FS1300
Stabilisation 3 Axis
Norad # 22871

INTELSAT 701
Located at 180 degrees E

Located 174E 10/93 to 8/97
Located 180E 9/97 to present.

TRANSPONDERS

C band	28
Power	10/16/20/30W
Bandwidth	10 x 36MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	P.O.R.
Polarisation	Circular
Ku Band	10
Power	5 x 35 watts
	5 x 55 Watts
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	P.O.R.
Polarisation	Linear



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

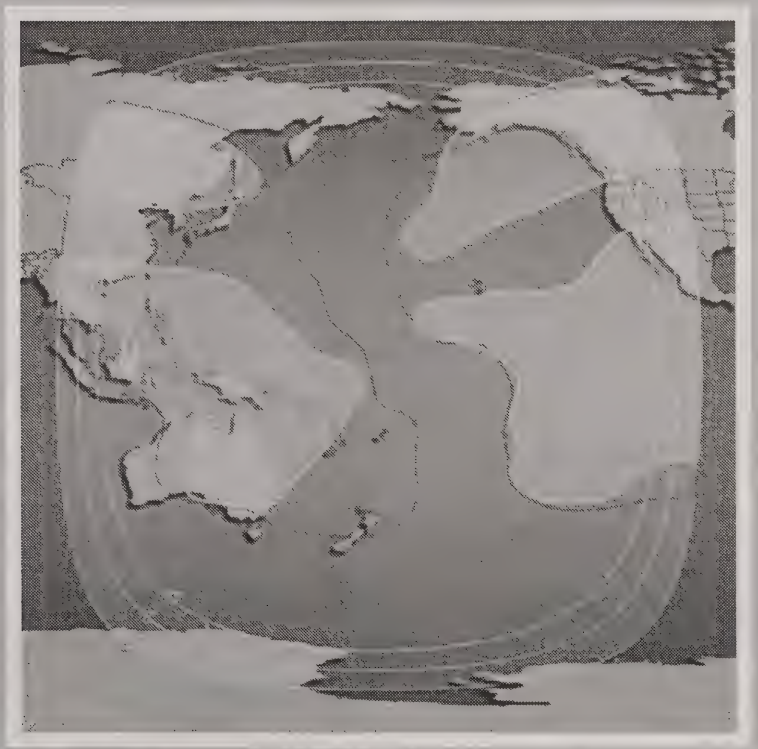
Launch Date 14/8/91	**Origin** International
Launch Vehicle Ariane V45	**Type** HS 389
Mass In Orbit 2560 Kg	**Stabilisation** Spin
Design Lifetime 13 years	**Norad #** 21653

INTELSAT 605
To be located 178 degrees E

Presently located at 332.5E
To be deployed at 178E during 2004

TRANSPONDERS

C band	38 + 12
Power	10/16 watts
Bandwidth	10 x 36MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	P.O.R
Polarisation	Circular
Ku Band	10 + 4
Power	11 x 20 watts
	3 x 40 Watts
Bandwidth	8 x 72 MHz
	4 x 150 MHz
Coverage	P.O.R.
Polarisation	Linear



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

Launch Date 22/12/97
Launch Vehicle Ariane V104
Mass In Orbit 1900 Kg
Design Lifetime 13 years

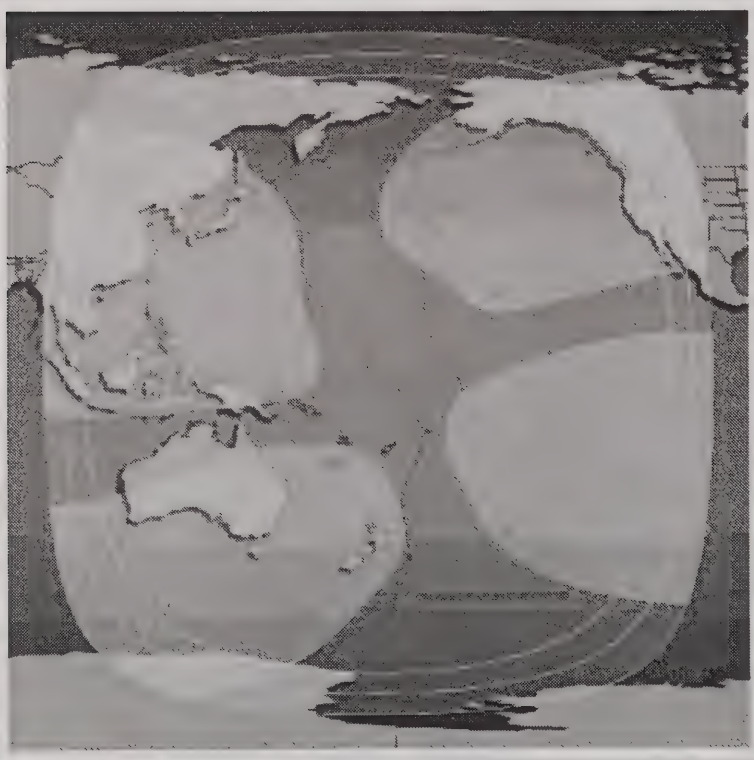
Origin International
Type GE 7000
Stabilisation 3 Axis
Norad # 25110

INTELSAT 804
Located at 176 degrees E

TRANSPONDERS

C band	38
Power	7 x 22 Watts
	27 x 38 Watts
Bandwidth	10 x 36MHz
	28 x 36/72 MHz
Coverage	P.O.R
Polarisation	Circular
Ku Band	6
Power	6 43 Watts
Bandwidth	72 112 MHz
Coverage	P.O.R.
Polarisation	Linear

Located 44E 12/97 to 02/02
Located 64E 02/02 to 10/02
Located 176E 11/02 to present



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

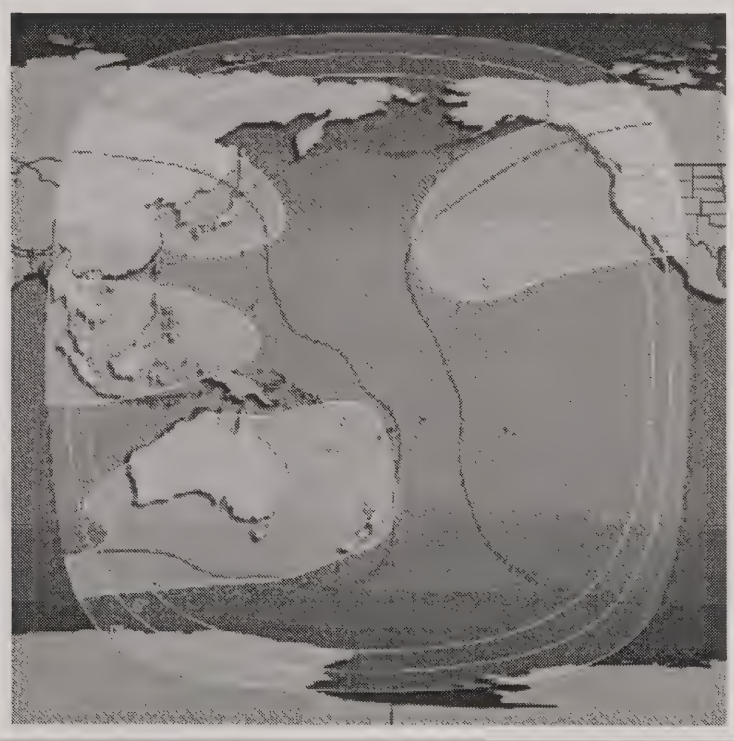
Launch Date 25/06/97
Launch Vehicle Ariane V96
Mass In Orbit 1900 Kg
Design Lifetime 15 years

Origin International
Type FS1300
Stabilisation 3 Axis
Norad # 24846

INTELSAT 802
Located at 174 degrees E

TRANSPONDERS

C band	38
Power	7 x 22 Watts
	27 x 38 Watts
Bandwidth	10 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	P.O.R.
Polarisation	Circular
Ku Band	10
Power	5 x 35 watts
	5 x 55 Watts
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	P.O.R
Polarisation	Linear



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

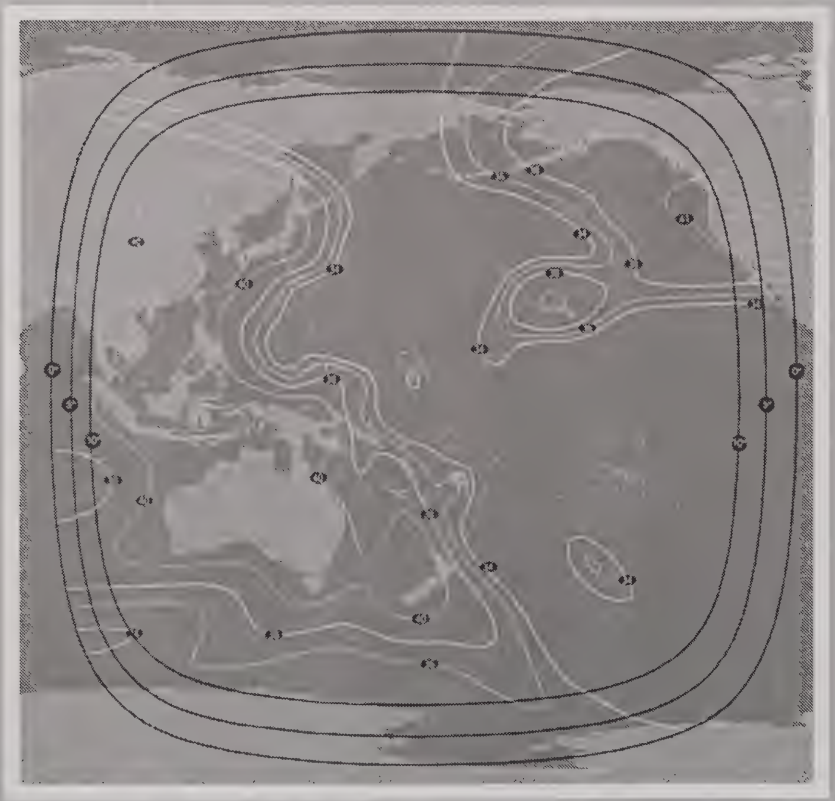
Launch Date 2005	**Origin** USA
Launch Vehicle Ariane 5ECA	**Type** Spacebus 4000
Launch Mass 4850 Kg	**Stabilisation** 3 Axis
Design Lifetime 15 years	**Norad #** TBA

WORLDSAT 3
To be located 172 degrees E

Prior to launch, services carried by Spacenet 4 at 172E. Originally called GE3i under GE-Americom ownership Renamed AMC-13 after SES purchased Americom. Renamed Worldsat 3 in 2004 after ownership transferred to Worldsat LLC. Satellite reconfigured for Worldsat, adding Ku band coverage for airborne broadband services.

TRANSPONDERS

C band	18
Power	80 W
Bandwidth	12 x 36MHz 6 x 72MHz
Coverage	USA, Asia Australia, NZ
Polarisation	Linear
Ku band	20
Power	138 W
Bandwidth	8 x 27 MHz 12 x 36 MHz 6 x 72 MHz
Coverage	POR



Footprint source: www.ses-americom.com

Satellite Data for Orbital Locations

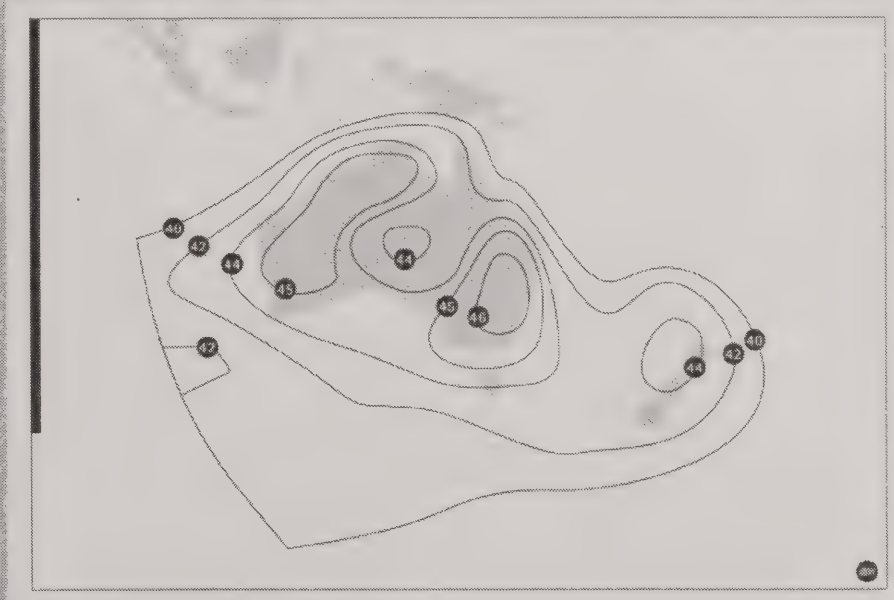
Launch Date 08/07/94
Launch Vehicle Ariane V65
Mass In Orbit 2920 Kg
Design Lifetime 15 years

Origin USA
Type HS-601
Stabilisation 3 Axis
Norad # 23175

PANAMSAT 2
Located at 169 degrees E

TRANSPONDERS

C band	16 + 4
Power	34 Watts
Bandwidth	12 x 54MHz 4 x 64 MHz
Coverage	Oceania/Pacific
Polarisation	Linear
Ku Band	16 + 4
Power	63 watts
Bandwidth	12 x 54 MHz 4 x 64 MHz
Coverage	China Australia, Asia
Polarisation	Linear



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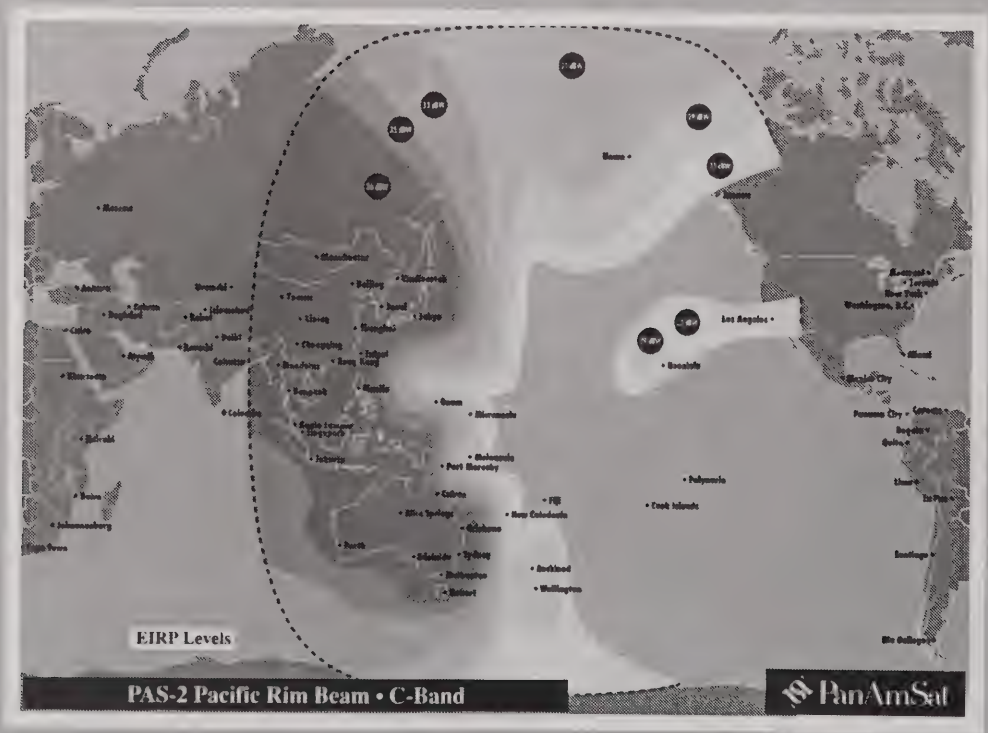
Satellite Data for Orbital Locations

Footprints source: Panamsat



Satellite Data for Orbital Locations

AUSTRALIA VERTICAL BEAM
Ku-Band

PanAmSat.

Footprint source: www.panamsat.com

Satellite Data for Orbital Locations

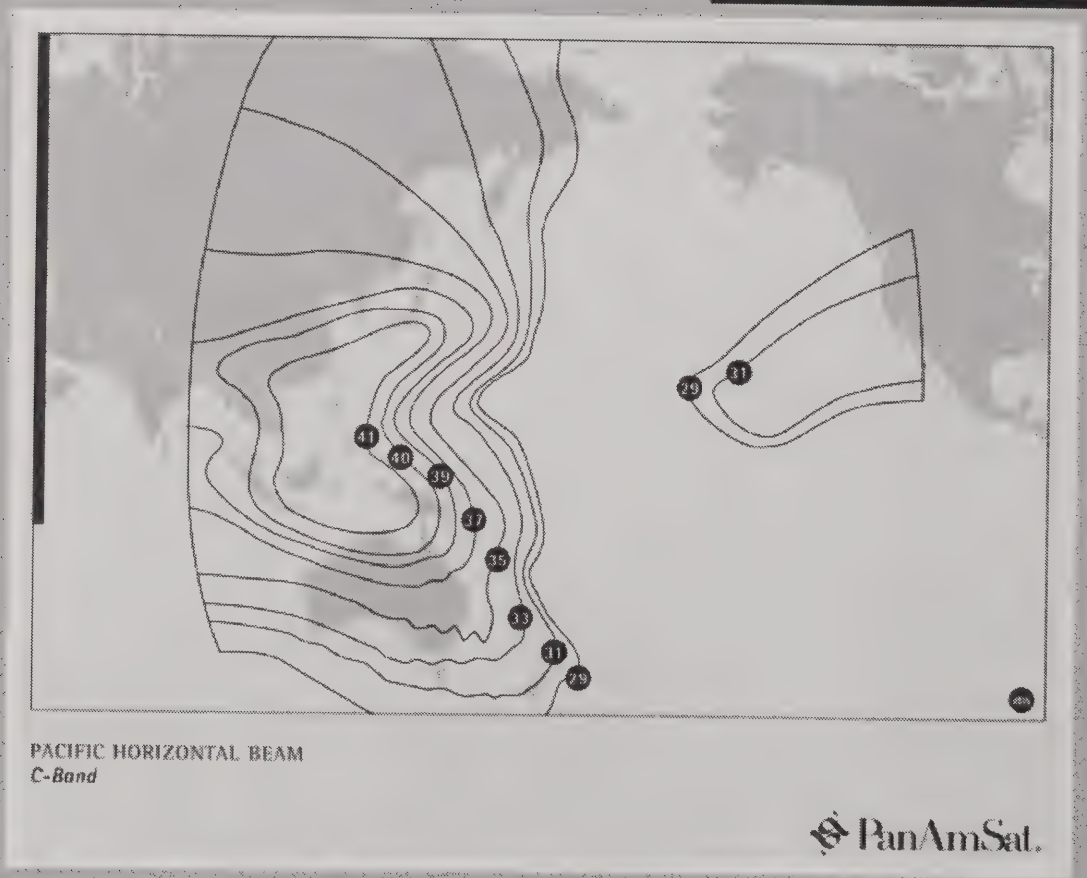
Launch Date 04/11/98
Launch Vehicle Proton #258
Mass In Orbit 1500 Kg
Design Lifetime 15 years

Origin USA
Type FS-1300
Stabilisation 3 Axis
Norad # 25522

PANAMSAT 8
Located at 166 degrees E

TRANSPONDERS

C band	24
Power	50 Watts
Bandwidth	24 x 36MHz
Coverage	Asia/Australia
Polarisation	Linear
Ku Band	24
Power	100 watts
Bandwidth	24 x 36 MHz
Coverage	Asia/Pacific
Polarisation	Linear



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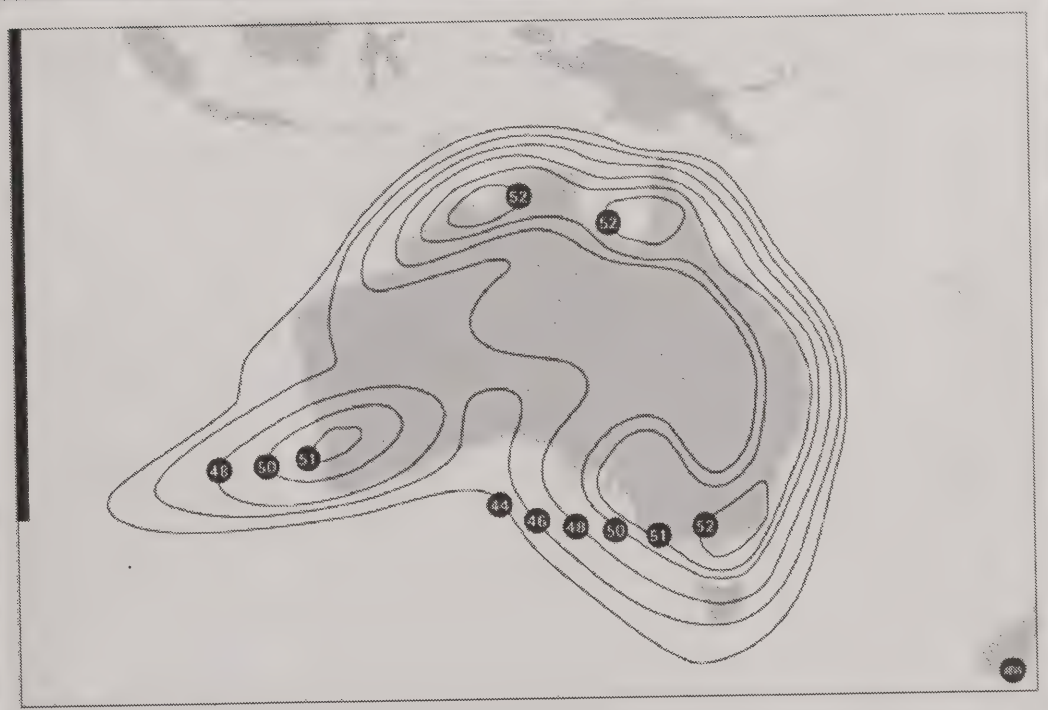
Satellite Data for Orbital Locations

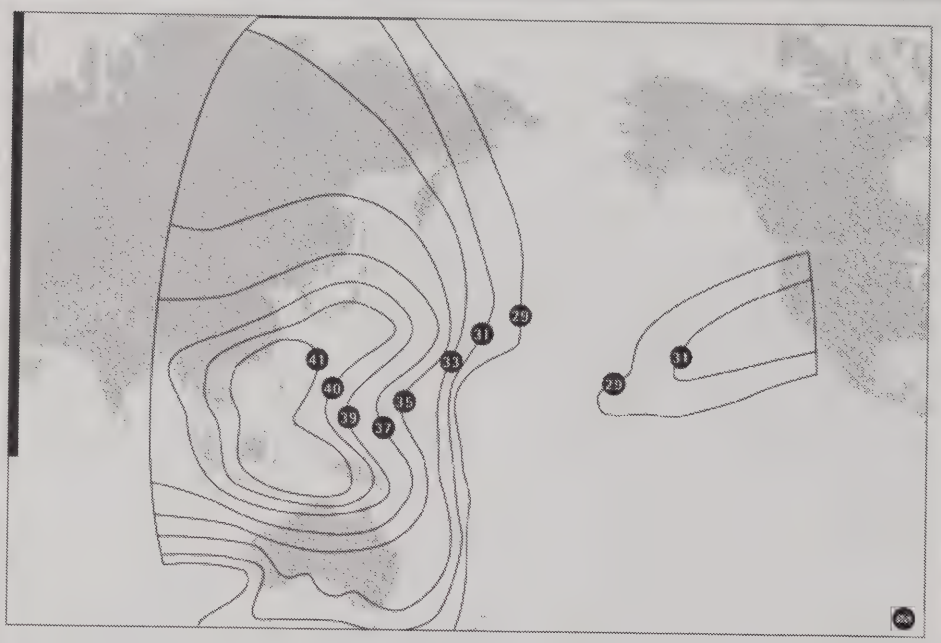


AUSTRALIA HORIZONTAL BEAM (CLOSE-UP VIEW)
Ku-Band

PanAmSat.

Footprint source: www.panamsat.com

Satellite Data for Orbital Locations



PACIFIC VERTICAL BEAM
C-Band

PanAmSat.

Footprint source: www.panamsat.com

AUSTRALIA HORIZONTAL BEAM
Ku-Band

PanAmSat.

Satellite Data for Orbital Locations

Launch Date 16/09/87
Launch Vehicle Ariane V19
Mass In Orbit 655 Kg
Design Lifetime 10 years

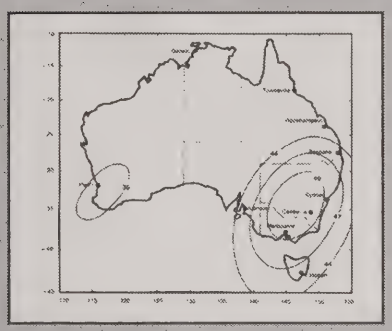
Origin Australia
Type HS-376
Stabilisation Spin
Norad # 18350

OPTUS A3
Located at 164 degrees E

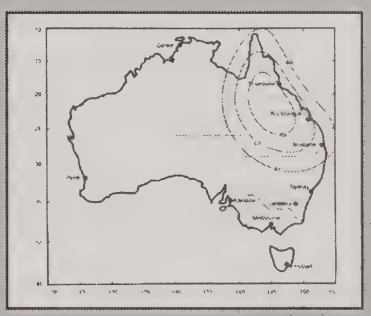
Originally called AUSSAT A3
Original location 164E
Feb 1995 moved to 156E
August 1995 moved to 152E inclined
July 1999 to present 164E inclined

TRANSPONDERS

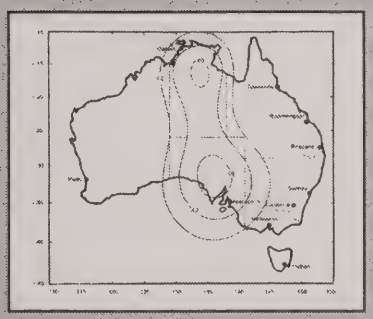
Ku Band	15
Power	12/30 watts
Bandwidth	15 x 45 MHz
Coverage	Australia / NZ PNG
Polarisation	Linear



SE beam

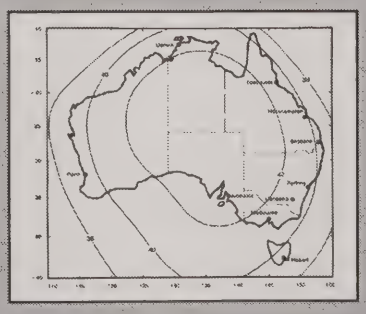


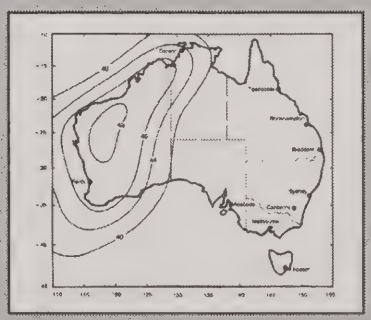
NE beam



Central Australian beam

National beam





W.A beam

Footprint source: Aussat Network Designers

Satellite Data for Orbital Locations

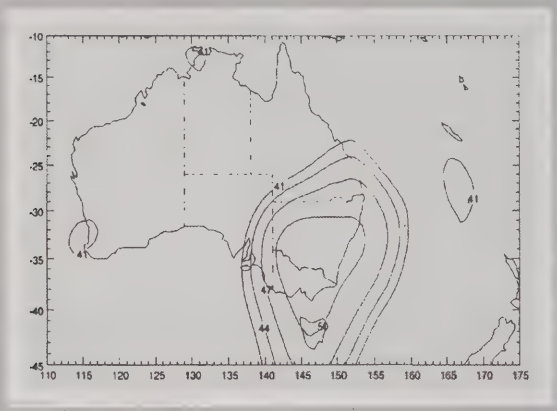
Launch Date 13/08/92
Launch Vehicle LM2E #16
Mass In Orbit 1582 Kg
Design Lifetime 15 years

Origin Australia
Type HS-601
Stabilisation 3 Axis
Norad # 22087

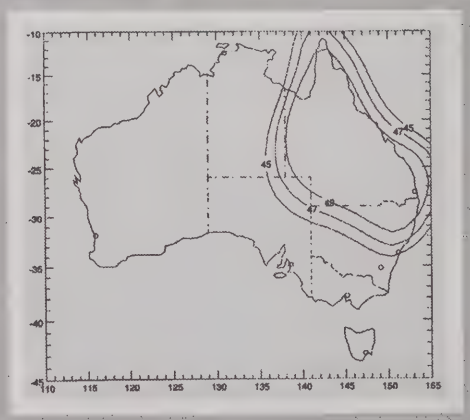
OPTUS B1
Located at 160 degrees E

TRANSPONDERS

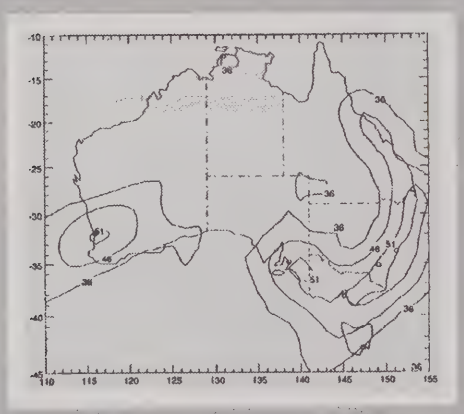
Ku Band	15
Power	50 watts
Bandwidth	15 x 54 MHz
Coverage	Australia
Polarisation	Linear



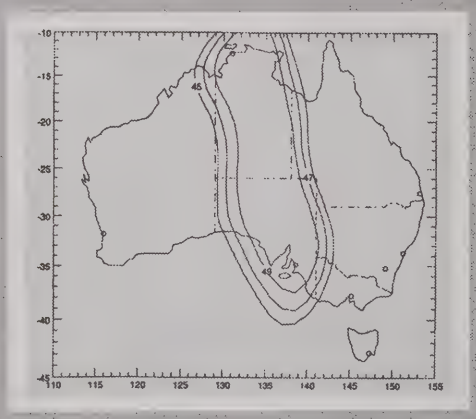
South East beam



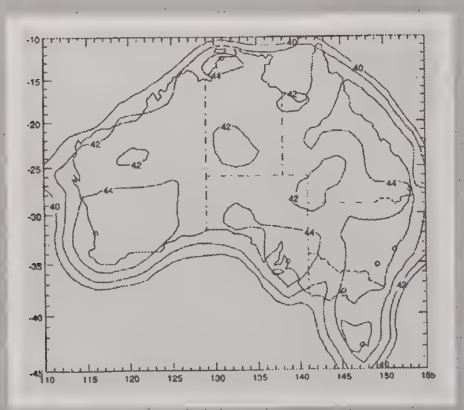
North East beam



High Performance beam



Central Australian beam



National beam

Footprint source:
Optus B Overview of Payload Performance

Satellite Data for Orbital Locations

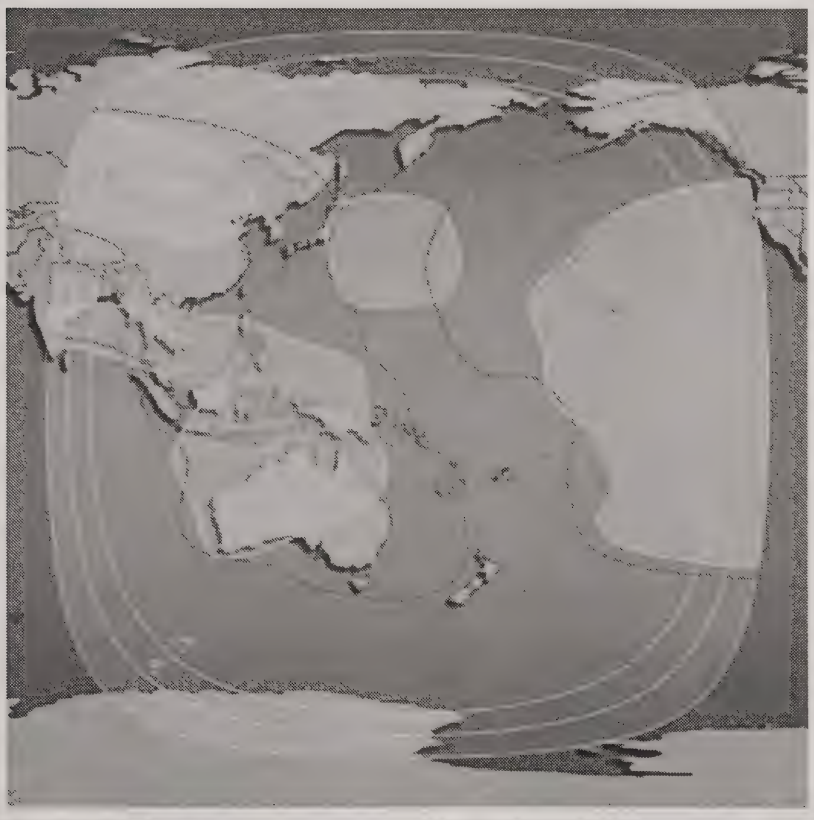
Launch Date 23/11/90
Launch Vehicle Titan 3 #155
Mass In Orbit 2560 Kg
Design Lifetime 15 years
Origin International
Type HS 389
Stabilisation 3 Axis
Norad # 20667

INTELSAT 604
Located at 157 degrees E

Located 38W 6/90
Located 27.5W 1/91 to 2/92
Located 60E 10/92 to 3/02
Located 157E 8/02 to present
Inclined orbit, will be replaced by I 709 in 2004

TRANSPONDERS

C band	38 (+12)
Power	16/10Watts
Bandwidth	36/41/72 MHz
Coverage	Asia/Australia
Polarisation	Circular
Ku Band	11 (+4)
Power	20/40 watts
Bandwidth	72/150 MHz
Coverage	Asia/Pacific
Polarisation	Linear



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

Launch Date 15/06/96
Launch Vehicle Ariane V87
Mass In Orbit 1800 Kg
Design Lifetime 13 years

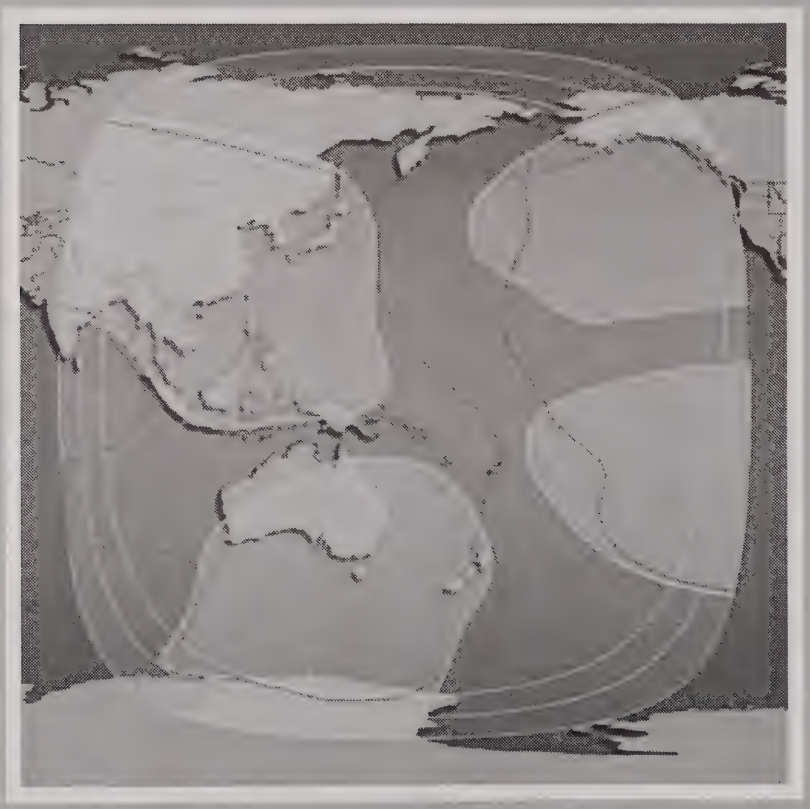
Origin International
Type FS1300
Stabilisation 3 Axis
Norad # 23915

INTELSAT 709
To be located 157 degrees E

Located 37.75W 6/94 to 4/96
Located 177E 05/96 to 10/00
Located 176E 10/00 to 12/02
Planned deployment 85E 2003
Planned deployment 157E 2004

TRANSPONDERS

C band	28
Power	10/16/20/30 W
Bandwidth	10 x 36MHz
	16 x 72 MHz
Coverage	P.O.R.
Polarisation	Circular
Ku Band	10
Power	5 x 35 watts
	5 x 55 Watts
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	POR
Polarisation	Linear



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

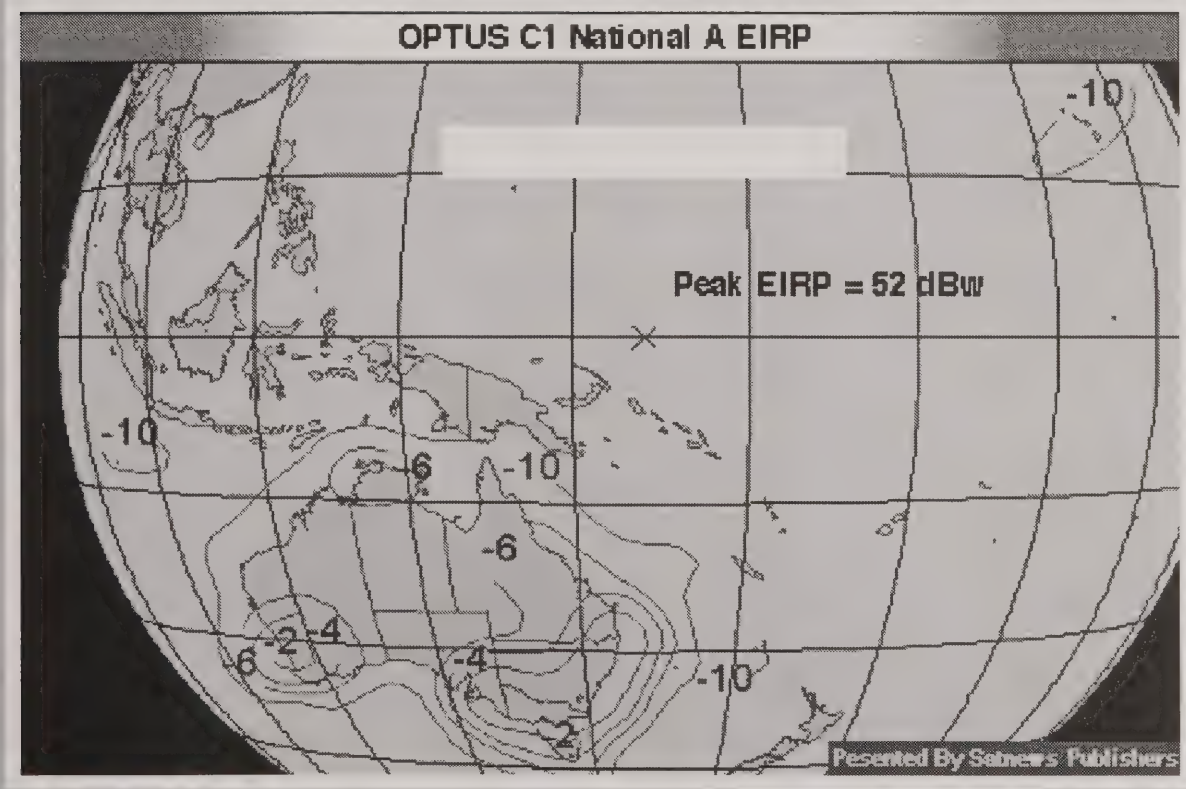
Launch Date 11/6/2003
Launch Vehicle Ariane 5G V161
Mass In Orbit 1582 Kg
Design Lifetime 15 years
Origin Australia
Type FS-1300
Stabilisation 3 Axis
Norad # 27831

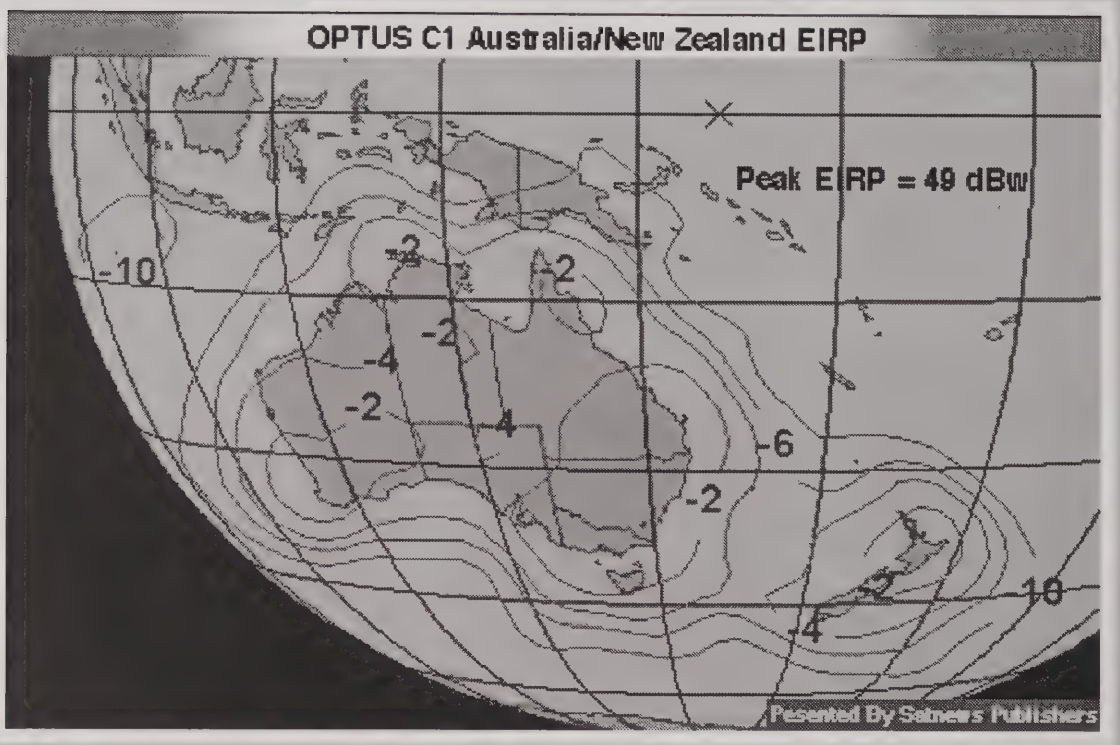
OPTUS C1
Located at 156 degrees E

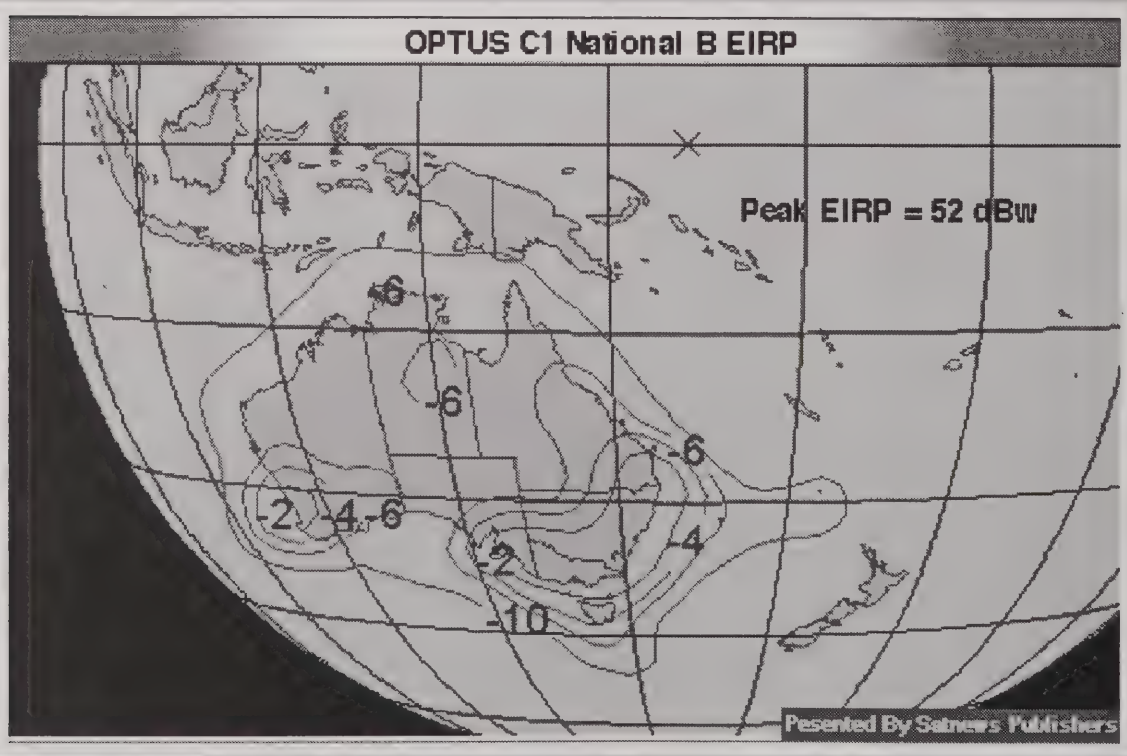
TRANSPONDERS

Ku Band	24
Power	50 watts
Bandwidth	16 x 36 MHz 8 x 72 MHz
Coverage	Australia /NZ S.E Asia, E Asia
Polarisation	Linear

Footrpint source: Satnews Publishers
Footprints unverified by Optus




OPTUS C1 Australia/New Zealand EIRP
Peak EIRP = 49 dBw
-10
-2
-2
-2
-4
-2
-4
-6
-2
-2
-4
10
Presented By Satnews Publishers


OPTUS C1 National B EIRP
Peak EIRP = 52 dBw
-6
-6
-6
-2
-4
-6
-2
-4
-10
Presented By Satnews Publishers

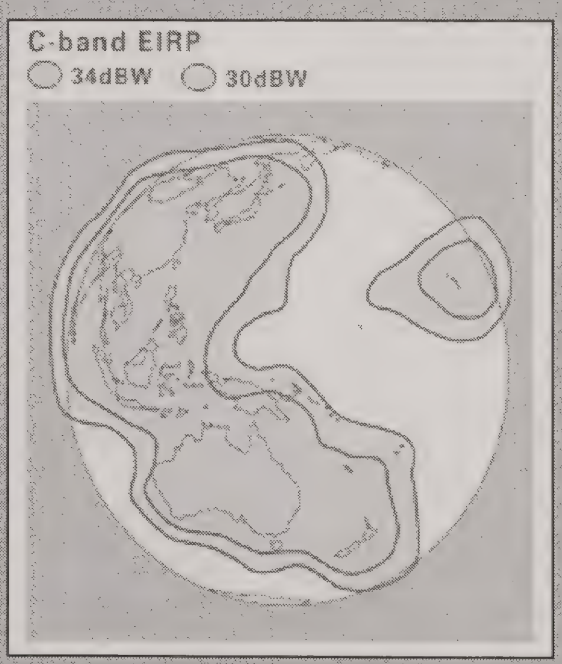
Satellite Data for Orbital Locations

Launch Date 29/03/02
Launch Vehicle Ariane V149
Mass In Orbit 1841Kg
Design Lifetime 11 years
Origin Japan
Type HS-601
Stabilisation 3 axis
Norad # 27399

JCSAT-2A
Located at 154 degrees E

TRANSPONDERS

C Band	16
Power	34 Watts
Bandwidth	11 x 36 MHz 5 x 54 MHz
Coverage	Japan, East Asia Oceania, Hawaii
Polarisation	Linear
Ku band	16
Power	120 Watts
Bandwidth	16 x 57 MHz
Coverage	Japan
Polarisation	Linear



Footprint source:www.iijnet.or.jp

Satellite Data for Orbital Locations

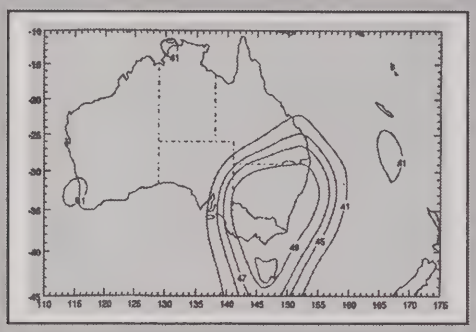
Launch Date 27/08/94
Launch Vehicle LM 2E #21
Mass In Orbit 1582 Kg
Design Lifetime 13 years

Origin Australia
Type HS-601
Stabilisation 3 Axis
Norad # 23227

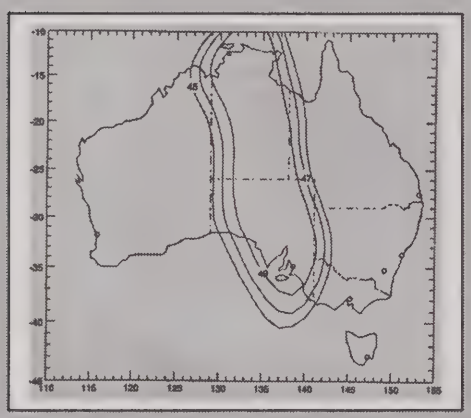
OPTUS B3
Located at 152 degrees E

TRANSPONDERS

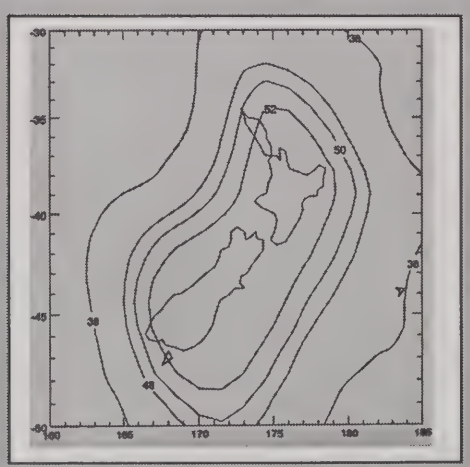
Ku Band	15
Power	50 watts
Bandwidth	15 x 54 MHz
Coverage	Australia/NZ
Polarisation	Linear



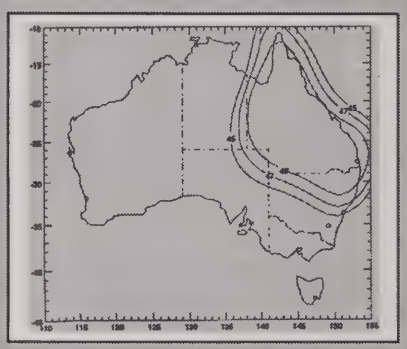
South East beam



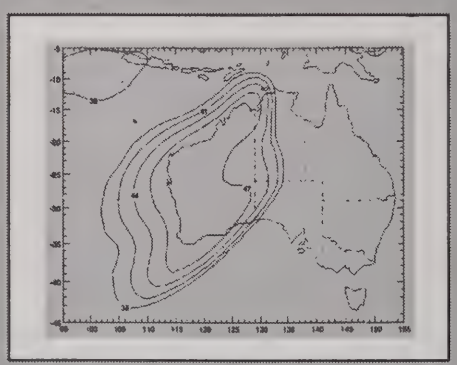
Central Australian beam



NZ beam

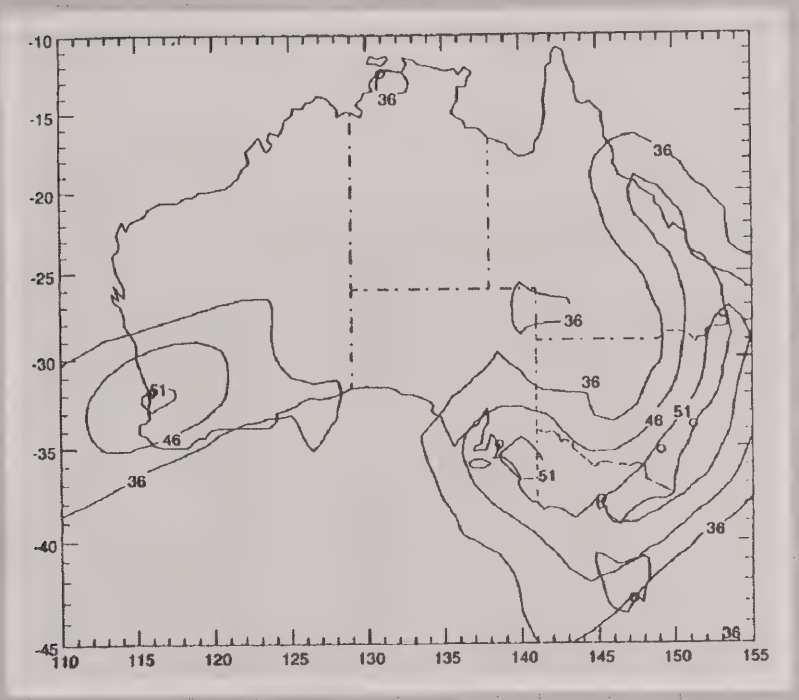


North East beam

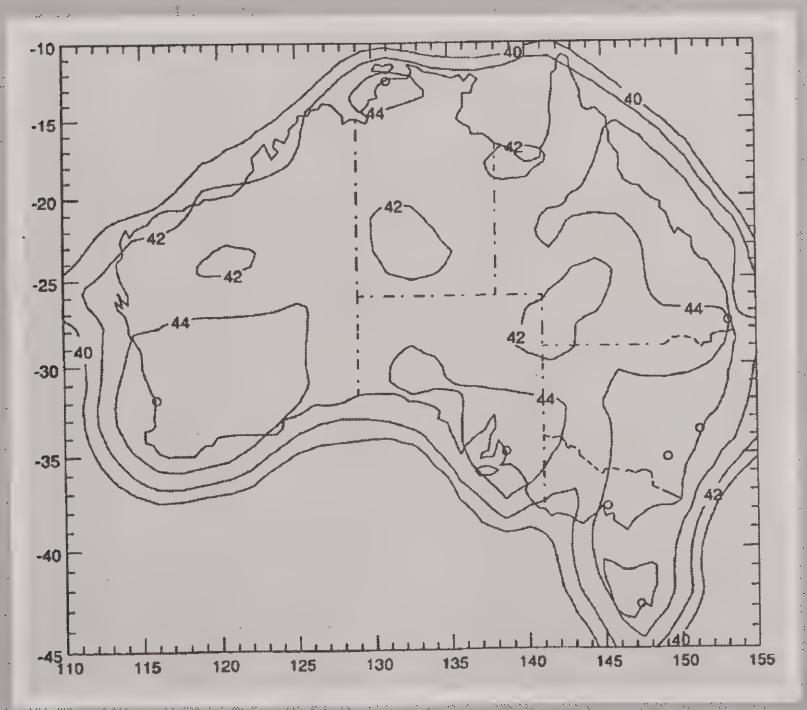


Western Australian beam

Satellite Data for Orbital Locations



High Performance beam



National beam

Footprint source: Optus B Overview of Payload Performance

Satellite Data for Orbital Locations

Launch Date 14/11/96
Launch Vehicle Ariane V92
Mass In Orbit 1450 Kg
Design Lifetime 11 years

Origin Malaysia
Type HS-376
Stabilisation Spin
Norad # 24653

MEASAT 2
Located at 148 degrees E

TRANSPONDERS

C Band	6
Power	12 Watts
Bandwidth	6 x 72 MHz
Coverage	Malaysia N Vietnam Australia Indonesia
Ku Band	9
Power	12 watts
Bandwidth	9 x 50 MHz
Coverage	Australia Philippines Taiwan Vietnam Indonesia
Polarisation	Linear

Footprint source: www.measat.com

Satellite Data for Orbital Locations

Launch Date 20/08/97
Launch Vehicle LM 3B #17
Mass In Orbit 1700 Kg
Design Lifetime 12 years

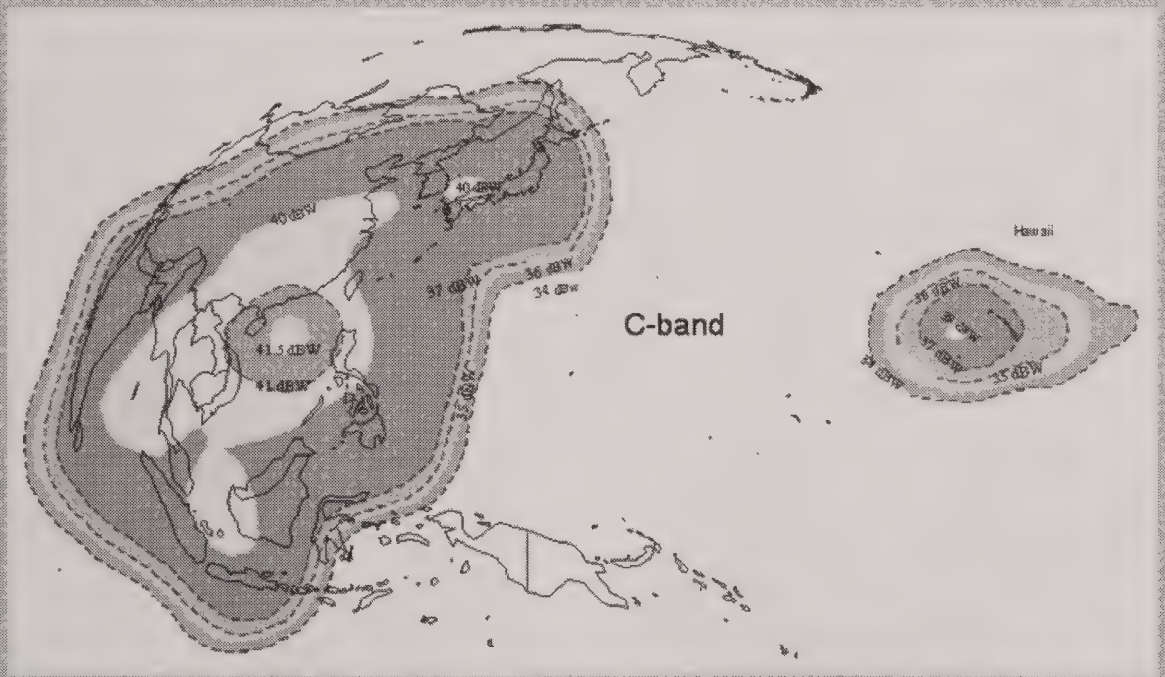
Origin Malaysia
Type FS-1300
Stabilisation 3 Axis
Norad # 24901

AGILA 2
Located at 146 degrees E

Plans to move to 147E.
C band signals observed in Sydney.

TRANSPONDERS

C Band	30 + 8
Power	27 Watts
Bandwidth	30 x 36 MHz
Coverage	Philippines
Polarisation	Linear
Ku Band	24 + 8
Power	110 Watts
Bandwidth	24 x 36 MHz
Coverage	Philippines China Taiwan N Vietnam
Polarisation	Linear



Footprint source: Mabuhay

Satellite Data for Orbital Locations

Launch Date 6/06/2000
Launch Vehicle Proton #273
Mass In Orbit 802 Kg
Design Lifetime 3 years

Origin CIS
Type NPO Gorizont
Stabilisation 3 Axis
Norad # 26372

GORIZONT 33 (#45)
Located at 145 degrees E

No North-South axis control, Inclined orbit.
29 Gorizont satellites have been successfully launched.
There have been 3 launch failures and one in orbit failure.

TRANSPONDERS

C band	6
Power	1 x 65 Watts
	5 x 10.5 Watts
Bandwidth	6 x 34 MHz
Coverage	Asia, CIS
Polarisation	LHCP
Ku Band	1
Power	1 x 20 Watts
Bandwidth	1 x 34 MHz
Coverage	CIS
Polarisation	Linear

Satellite operated by the Russian Satellite Communications Company

Satellite Data for Orbital Locations

Launch Date 25/01/1996	**Origin** CIS
Launch Vehicle Proton #239	**Type** NPO Gorizont
Launch Mass 2120 Kg	**Stabilisation** 3 Axis
Design Lifetime 3-5 years	**Norad #** 23775

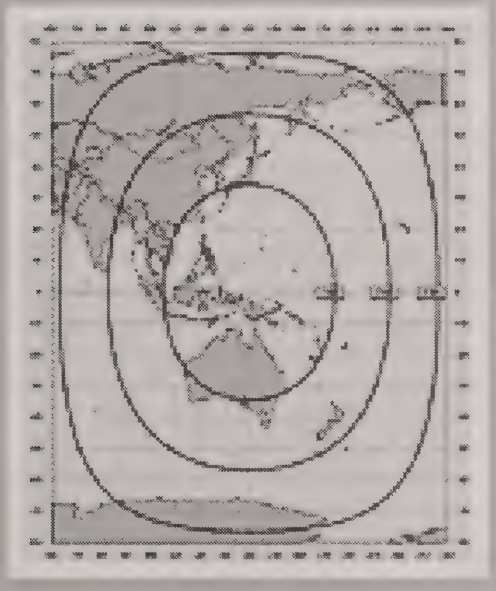
GORIZONT 31
Located at 140 degrees E

No North-South axis control.
Inclined orbit.

TRANSPONDERS

C band	6
Power	1 x 40 Watts
	5 x 15 Watts
Bandwidth	5 x 27 MHz
Coverage	Asia, CIS
Polarisation	RHCP
Ku Band	1
Power	1 x 20 Watts
Bandwidth	1 x 36 MHz
Coverage	CIS
Polarisation	Linear

Photo source: Av-Comm



Footprints source: RSCC

Satellite Data for Orbital Locations

Launch Date 21/07/95
Launch Vehicle LM3 #10
Mass In Orbit 560 Kg
Design Lifetime 10 years

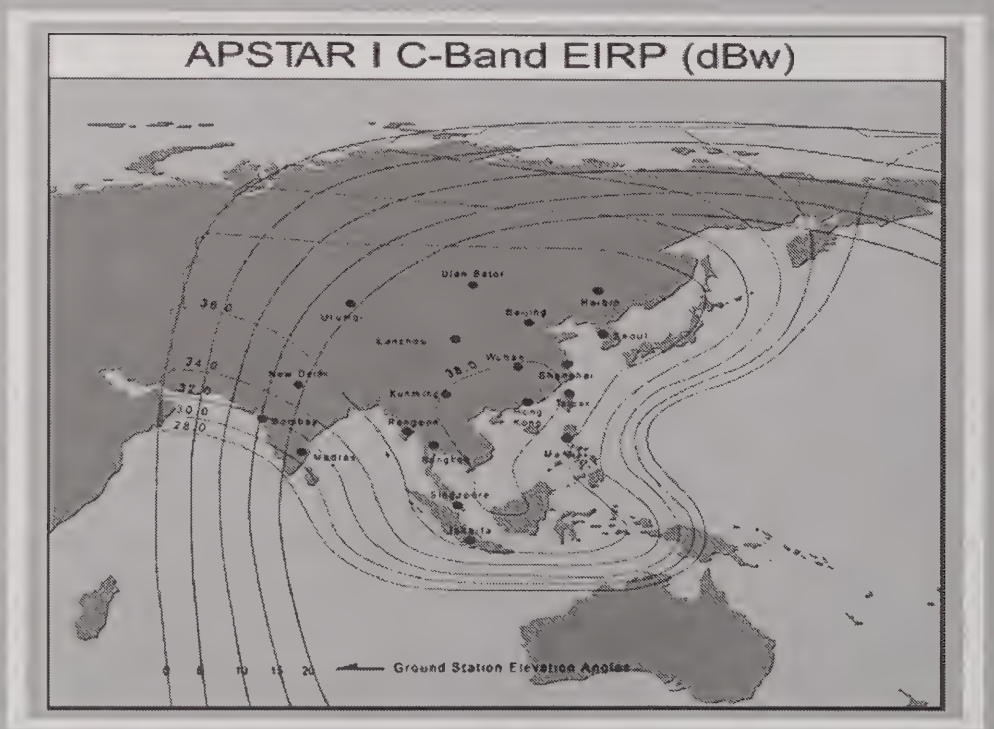
Origin Malaysia
Type HS-376
Stabilisation Spin
Norad # 23185

APSTAR 1
Located at 138 degrees E

TRANSPONDERS

C Band	24 + 6
Power	16 Watts
Bandwidth	20 x 36 MHz 4 x 72 MHz
Coverage	N & SE Asia
Polarisation	Linear

Will be replaced by Apstar V to be launched Q3 2004



Footprint source:http://business.singtel.com/satellite

Satellite Data for Orbital Locations

Launch Date Q3 2004
Launch Vehicle Zenit 3SL #14
Mass In Orbit 4845 Kg
Design Lifetime 13 years

Origin International
Type LS-1300
Stabilisation 3 axis
Norad # TBA

APSTAR V / TELSTAR 18
Located at 138 degrees E

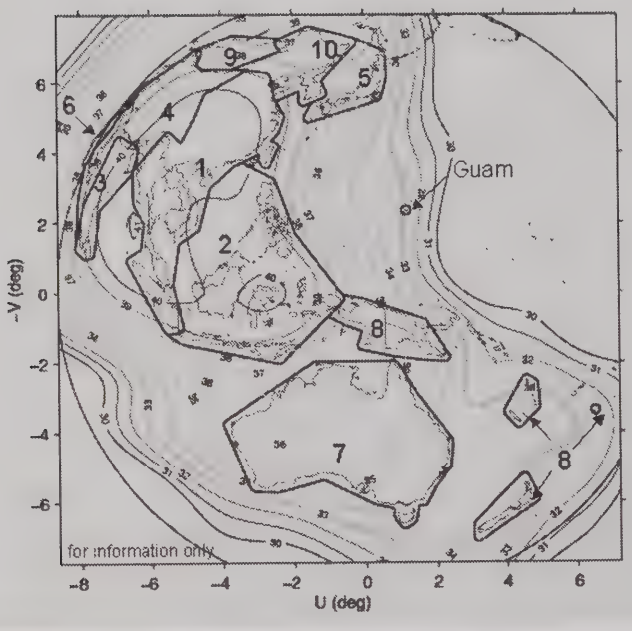
TRANSPONDERS

C Band	38
Power	60 Watts
Bandwidth	38 x 36 MHz
Coverage	China, India, SE Asia Australia, Hawaii Guam, South Pacific
Polarisation	Linear
K band	16
Power	139 Watts
Bandwidth	16 x 36MHz
Coverage	China, Hong Kong Macau, Taiwan
Polarisation	Linear

Jointly owned by Loral Space & Communications and APT Satellite Company.
Will replace Apstar 1

Satellite Data for Orbital Locations

C STANDARD BAND EIRP

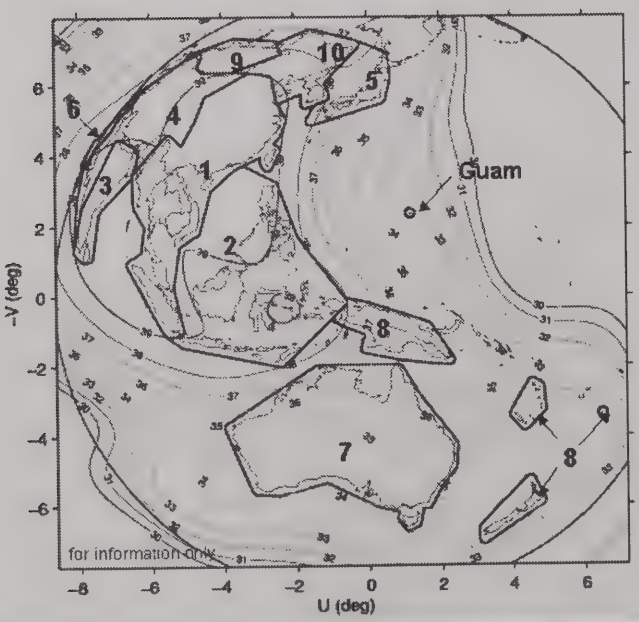


Region	Spec. (dBw)
1	39
2	38
3	39
4	38
5	33
6	34
7	34
8	33
9	33
10	37
Guam	33
Honolulu	36

Note: With 53W TWTA

Footprints source: APT Satellite

C EXTENDED BAND EIRP



Region	Spec. (dBw)
1	39
2	38
3	39
4	38
5	33
6	34
7	34
8	33
9	33
10	37
Guam	33
Honolulu	36

Note: With 60W TWTA

Satellite Data for Orbital Locations

Launch Date 03/07/96	**Origin** Hong Kong
Launch Vehicle LM3 #13	**Type** HS-376
Mass In Orbit 560 Kg	**Stabilisation** Spin
Design Lifetime 10 years	**Norad #** 23943

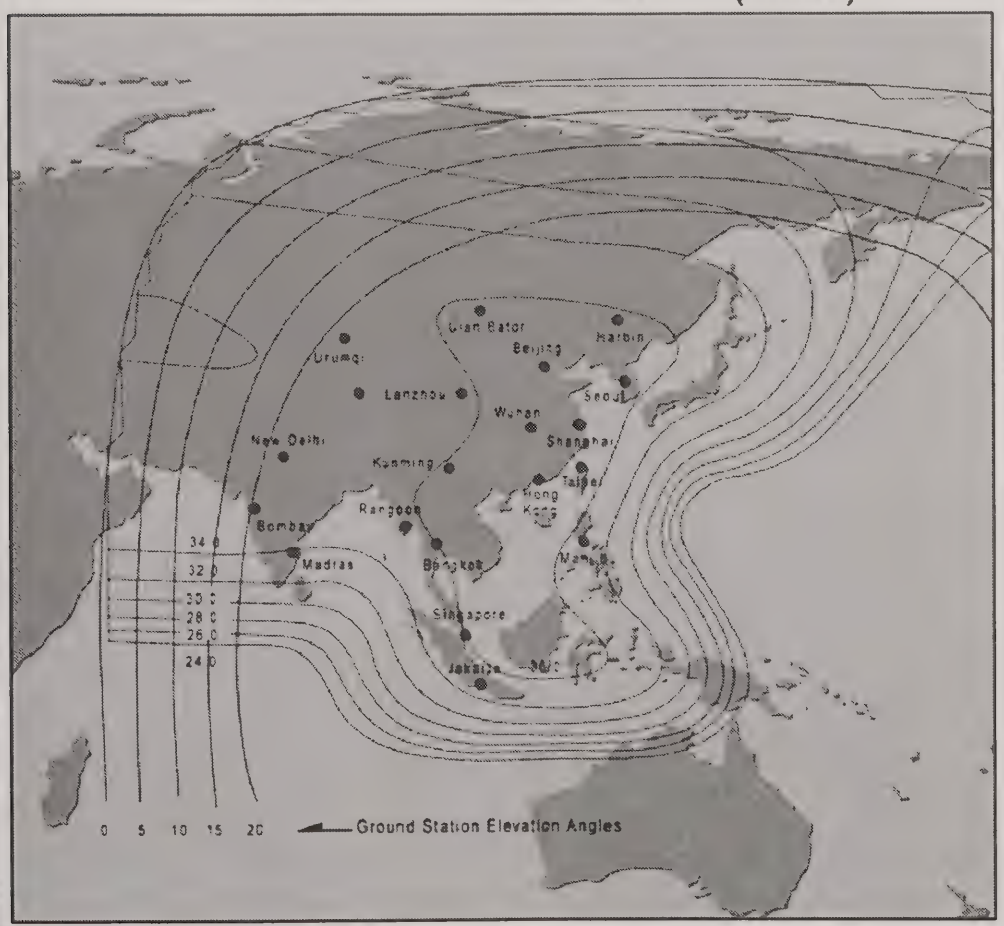
APSTAR 1A
Located at 134 degrees E

TRANSPONDERS

C Band	24 + 6
Power	16 Watts
Bandwidth	20 x 36 MHz 4 x 72 MHz
Coverage	India / SE Asia
Polarisation	Linear

Will be replaced by Apstar-V1 in 2005

APSTAR IA C-Band EIRP (dBw)



Footprint courtesy APT Satellite

Satellite Data for Orbital Locations

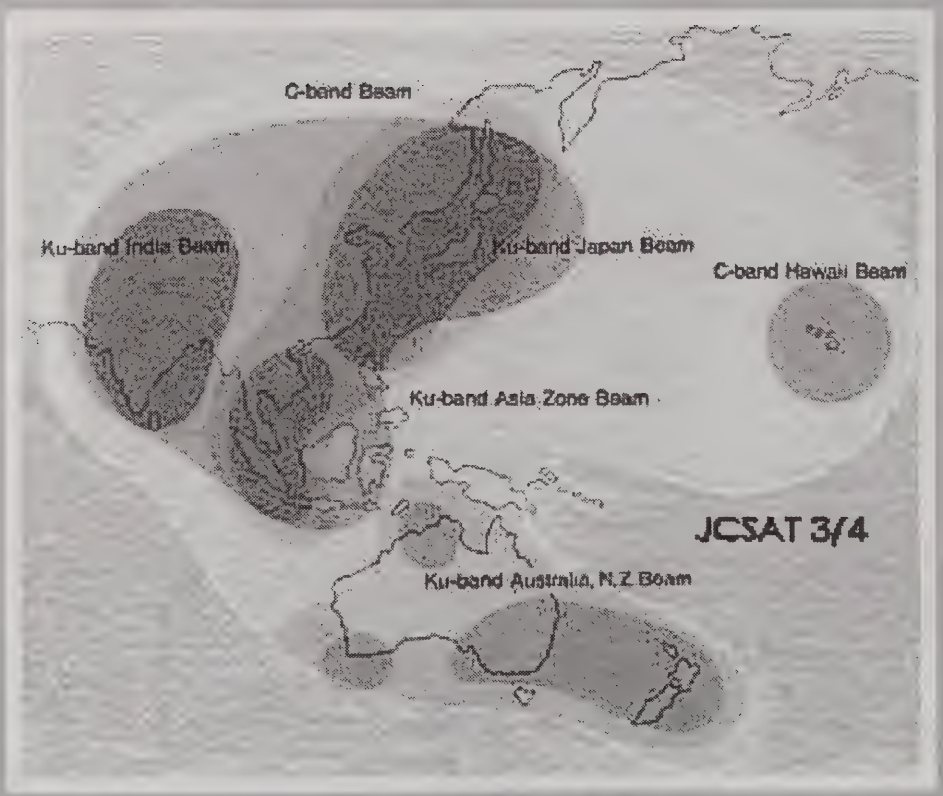
Launch Date 29/09/95	**Origin** Japan
Launch Vehicle Atlas Centaur #94	**Type** HS-601
Mass In Orbit 1841Kg	**Stabilisation** 3 axis
Design Lifetime 12 years	**Norad #** 23649

JCSAT-3
Located at 128 degrees E

Co-located with JCSAT-R a Boeing 601 in orbit spare, launched Feb 17 1997

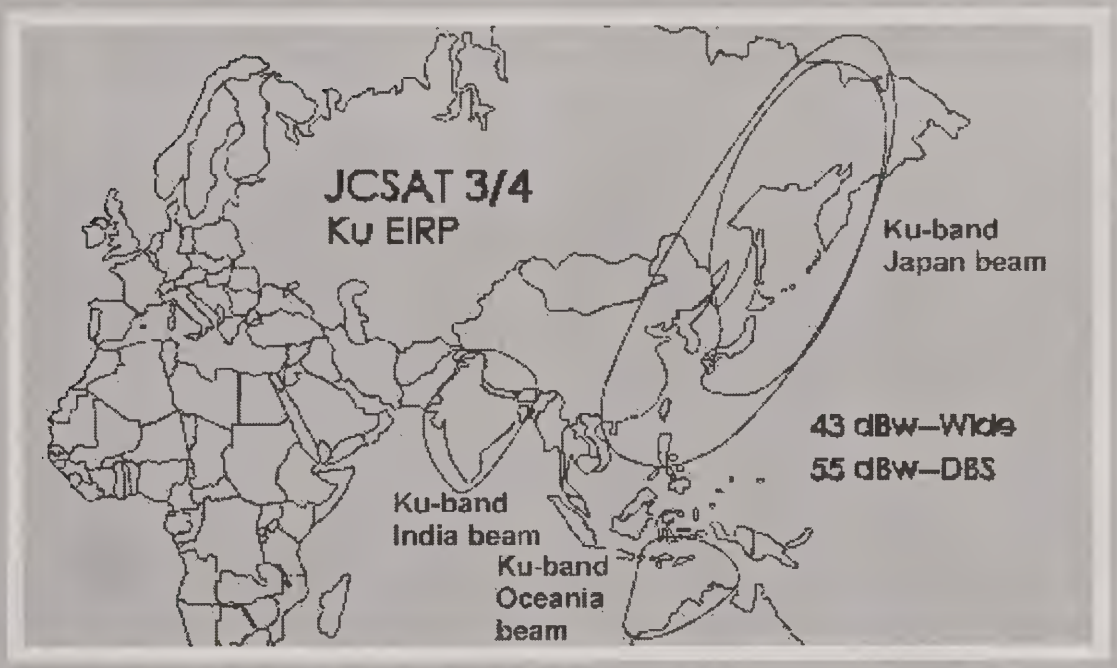
TRANSPONDERS

C Band	12
Power	34 Watts
Bandwidth	12 x 36 MHz
Coverage	Asia, Australia
Polarisation	Linear
Ku band	28
Power	60 Watts
Bandwidth	16 x 27 MHz 12 x 36 MHz
Coverage	East Asia, India Australia
Polarisation	Linear



Footprints source: www.jsat.net

Satellite Data for Orbital Locations



Footprints source: www.jsat.net

Satellite Data for Orbital Locations

Launch Date 12/04/2003
Launch Vehicle Atlas 3B #140
Mass In Orbit 2500 Kg
Design Lifetime 15 years

Origin Hong Kong
Type HS 601HP
Stabilisation 3 Axis
Norad # 27718

ASIASAT 4
Located at 122 degrees E

TRANSPONDERS

C band	28 + 6
Power	55 Watts
Bandwidth	28 x 36MHz
Coverage	Asia
Polarisation	Linear
Ku Band	20 + 4
Power	138 Watts
Bandwidth	16 x 54 MHz
Coverage	East Asia, Australia
Polarisation	Linear

Footprint source: www.asiasat.com

Satellite Data for Orbital Locations

Launch Date: Q3 2004
Launch Vehicle: Ariane 5GS
Mass: 6700Kg
Design Lifetime: 12 years

Origin: Thailand
Type: LS1300 SX
Stabilisation: 3 Axis
Norad #: TBA

iPSTAR–1
To be located 120 degrees E

Revolutionary broadband Internet connectivity by satellite.

Key Features

- iPSTAR is a satellite system designed for high speed two-way broadband communication over the IP platform and fully supports normal internet connection and any IP applications
- The connection via iPSTAR is "always on"
- An iPSTAR terminal will be able to access the internet at very high speed, subject to the class of service chosen, up to 8 Mbps forward /2.5 Mbps return per iPSTAR terminal
- The access speed of the iPSTAR system can be classified per Class of Service (CoS) to match the users' requirements and consume bandwidth efficiently.

iPSTAR Advantages over Terrestrial Broadband:

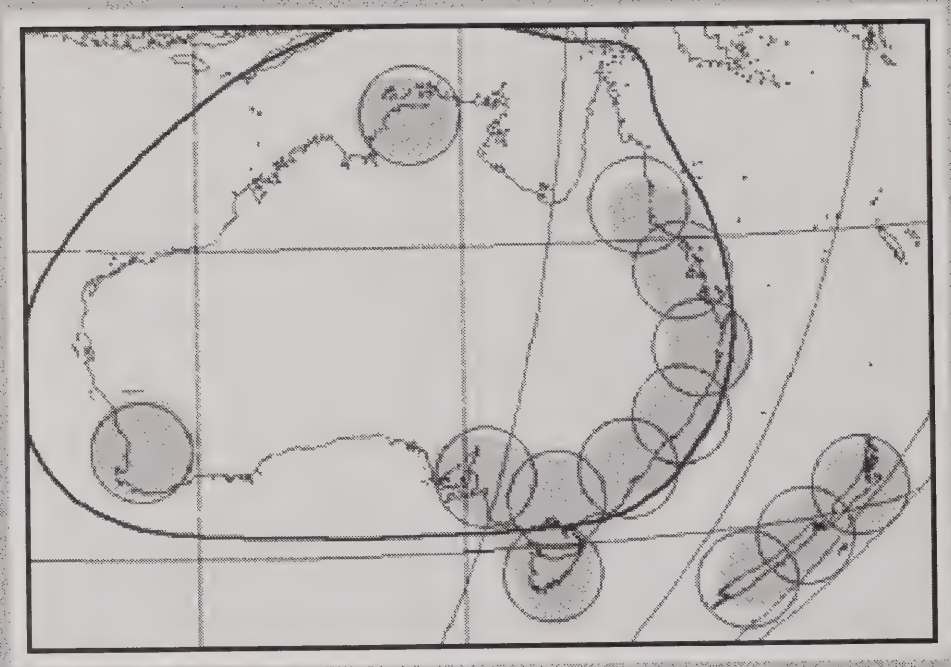
- iPSTAR will provide nationwide internet coverage with uniform access, quality and price
- terrestrial line speed or coverage limitation, and congestion can be bypassed
- iPSTAR allows Bandwidth On Demand (BOD) and Burstable speed
- iPSTAR Internet Access is a fast and low cost service deployment
- fast bandwidth upgrade
- Application platform on top of baseline broadband access

General Service Types for iPSTAR Terminals

Class of Service			
Download Speed	128 kbps	256 kbps	512 kbps
Upload Speed	64 Kbps	128 Kbps	128 Kbps
Sharing Ratio	1:1	1:1	1:1

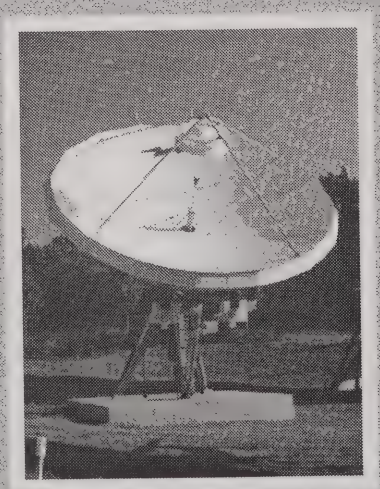
Class of Service			
Download Speed	256kbps	1 Mbps	2 kbps
Upload Speed	128 Kbps	256 Kbps	512 Kbps
Sharing Ratio	80:1	40:1	20:1

Satellite Data for Orbital Locations



Footprint source: www.thaicom.net/ipstar

Andrew Corporation have been awarded the contract to supply 18 earth stations in Australia, New Zealand and Asia. Earth Stations will comprise one 10 metre and one 7.6 metre dish. The satellite will carry the equivalent to 87 Ku and 10 Ka band transponders



Andrew 7.6m dish

Gateway

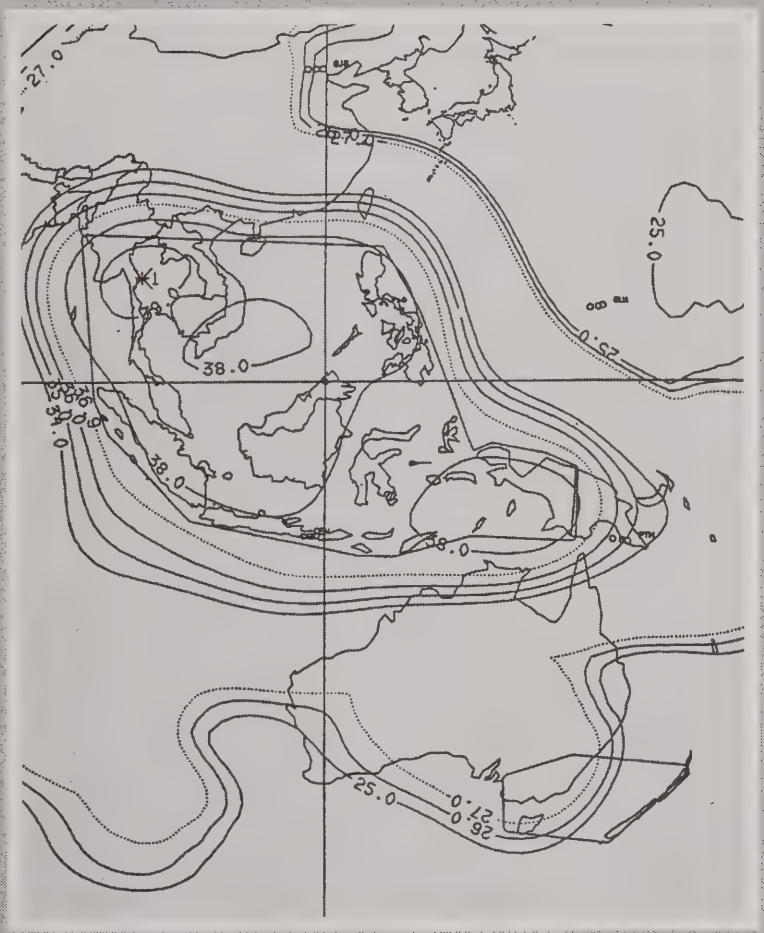
Satellite Data for Orbital Locations

Launch Date 16/05/96	**Origin** Indonesia
Launch Vehicle Ariane V86	**Type** HS-601
Mass In Orbit 1800 Kg	**Stabilisation** 3 Axis
Design Lifetime 14 years	**Norad #** 23864

PALAPA C2
Located at 113 degrees E

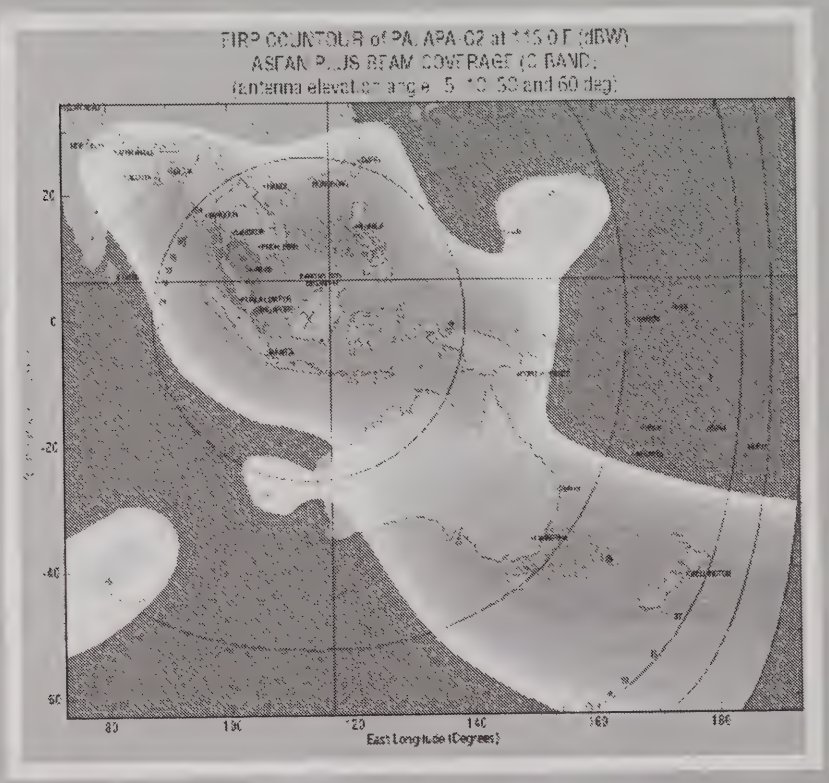
TRANSPONDERS

C band	30 + 8
Power	21.5 / 26.5 W
Bandwidth	30 x 36 MHz
Coverage	Indonesia Asia Australia PNG / NZ
Polarisation	Linear
Ku Band	4 + 2
Power	130 watts
Bandwidth	72 MHz
Coverage	Indonesia Hong Kong
Polarisation	Linear



Footprint source: Satelindo

Satellite Data for Orbital Locations



Footprint source:
Satelindo

Satellite Data for Orbital Locations

Launch Date 18/07/98
Launch Vehicle LM3B #51
Mass In Orbit 1600 Kg
Design Lifetime 15 years

Origin China
Type Spacebus 3000
Stabilisation 3 Axis
Norad # 25404

SINOSAT 1 / APR-2
Located at 110 degrees E

Will be replaced by Apstar-V1 in 2005

TRANSPONDERS

C band	24 + 8
Power	21 Watts
Bandwidth	32 x 36MHz
Coverage	China, Indonesia
Polarisation	Linear
Ku Band	15 + 4
Power	97 Watts
Bandwidth	19 x 54 MHz
Coverage	China Hong Kong Taiwan
Polarisation	Linear

Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

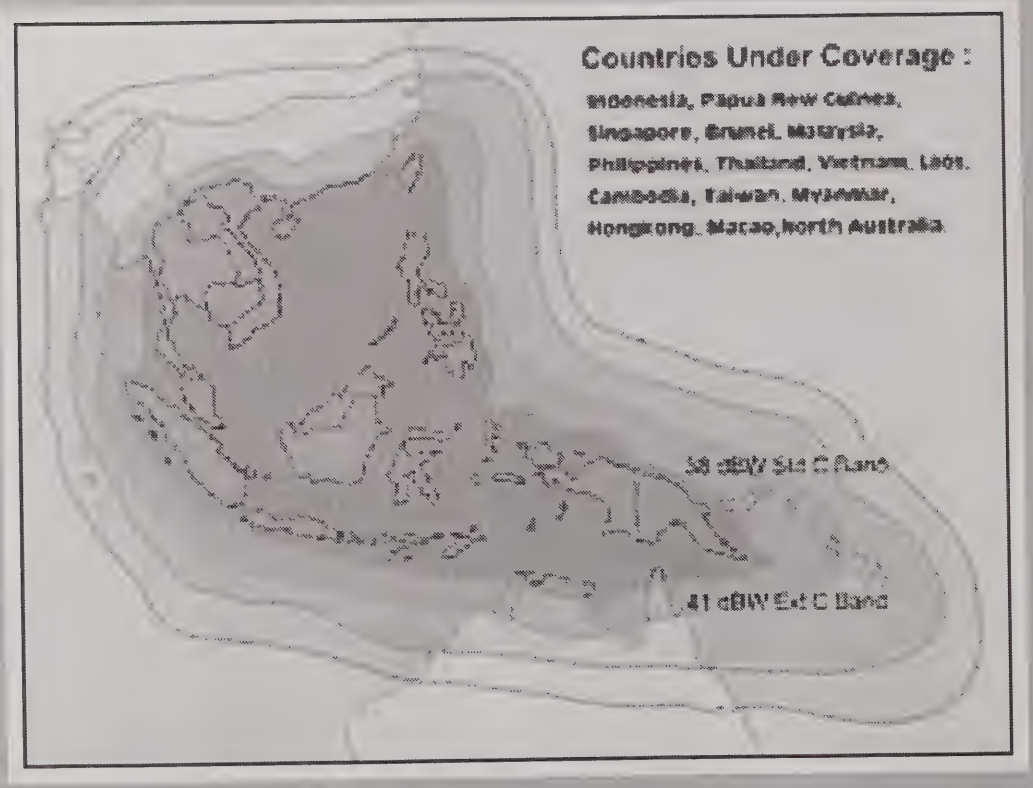
Launch Date 12/08/99
Launch Vehicle Ariane V118
Mass In Orbit 1700 Kg
Design Lifetime 15 years

Origin Indonesia
Type LM A2100
Stabilisation 3 axis
Norad # 25880

TELKOM 1 / Palapa D1
Located at 108 degrees E

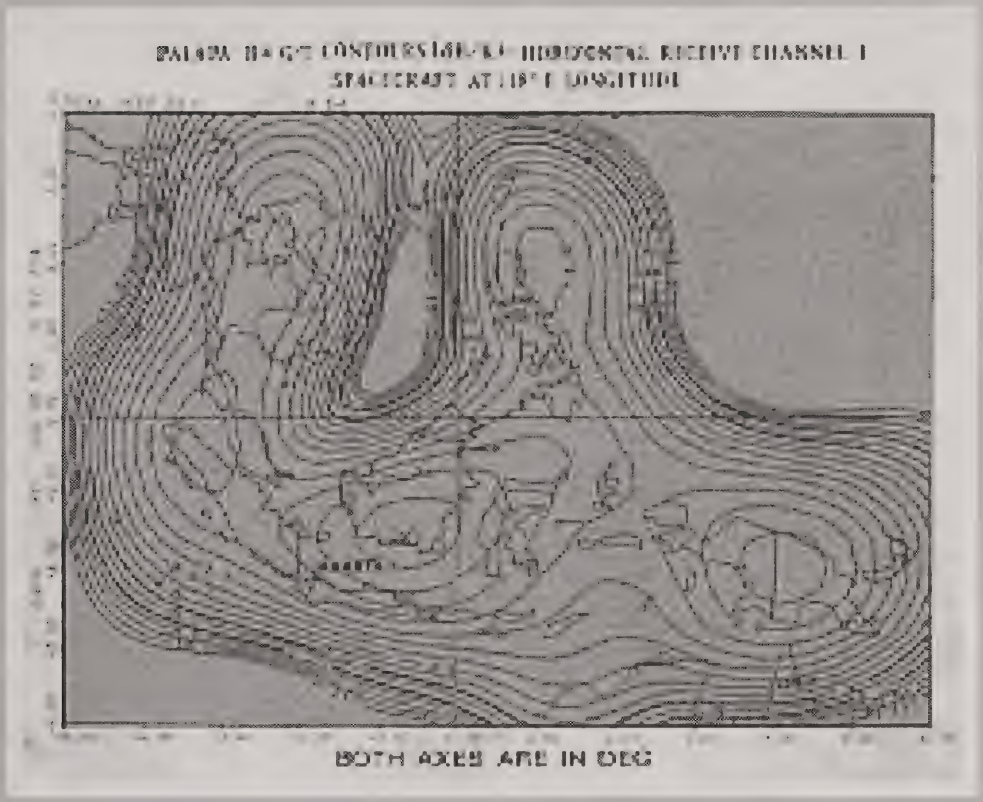
TRANSPONDERS

C band	36
Power	unknown
Bandwidth	36 x 36 MHz
Coverage	Indonesia Australia
Polarisation	Linear

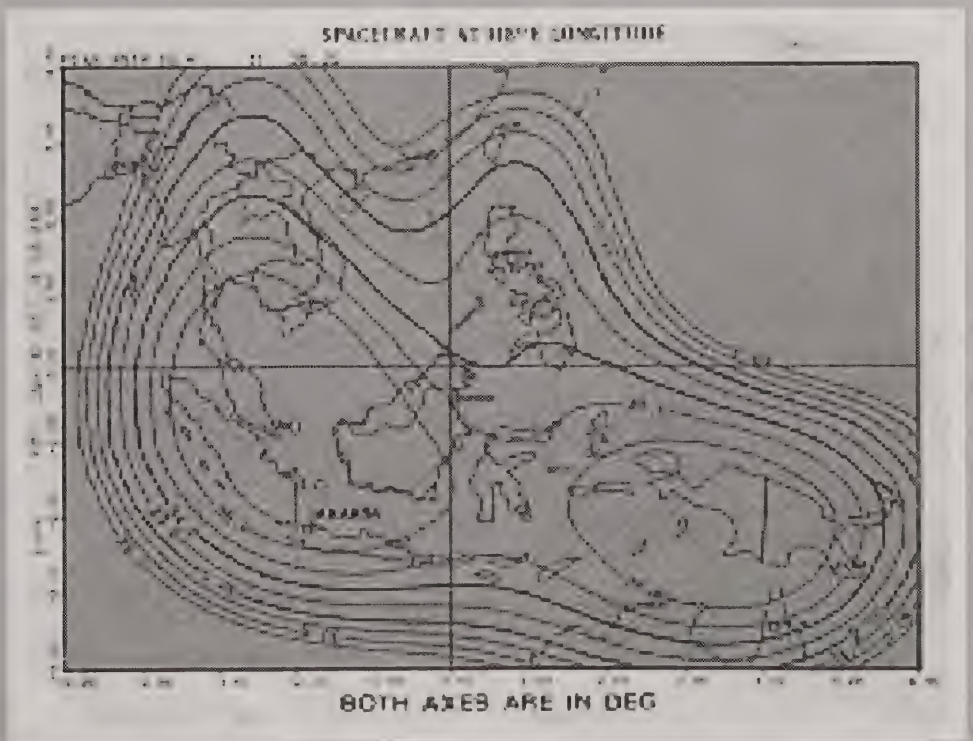


Footprint source: PT Telekomunikasi Indonesia Tbk

Satellite Data for Orbital Locations



Footprint source: PT Telekomunikasi Indonesia



Satellite Data for Orbital Locations

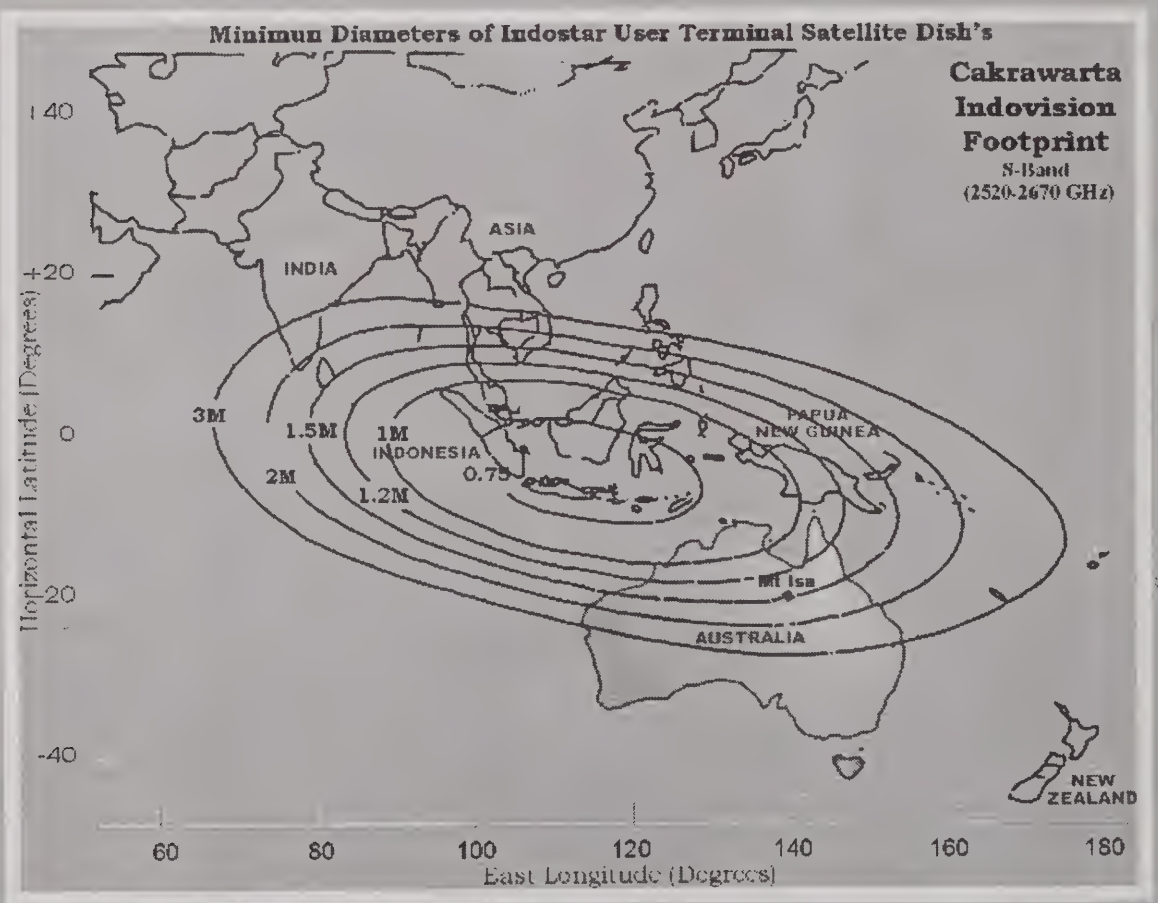
Launch Date 12/11/97	**Origin** Indonesia
Launch Vehicle Ariane V102	**Type** Starbus
Mass In Orbit 802 Kg	**Stabilisation** Spin
Design Lifetime 10 years	**Norad #** 25050

CAKRAWARTA
Located at 107.7 degrees E

TRANSPONDERS

S band	5
Power	70 Watts
Bandwidth	5 x 27 MHz
Coverage	Indonesia Australia
Polarisation	Linear

Previously called Indostar 1
PT Datakom Asia admitted in April 1998 that technical problems on its Cakrawarta-1 satellite led to difficulties with its energy supply. Because of a failed power regulator, two of the satellite's five transponders cannot be used whenever the satellite is eclipsed by the Earth. During these periods, only 80 percent of the required power is available.



Footprint source: Indovision

Satellite Data for Orbital Locations

Launch Date 21/03/99
Launch Vehicle Proton #263
Mass In Orbit 2500 Kg
Design Lifetime 15 years

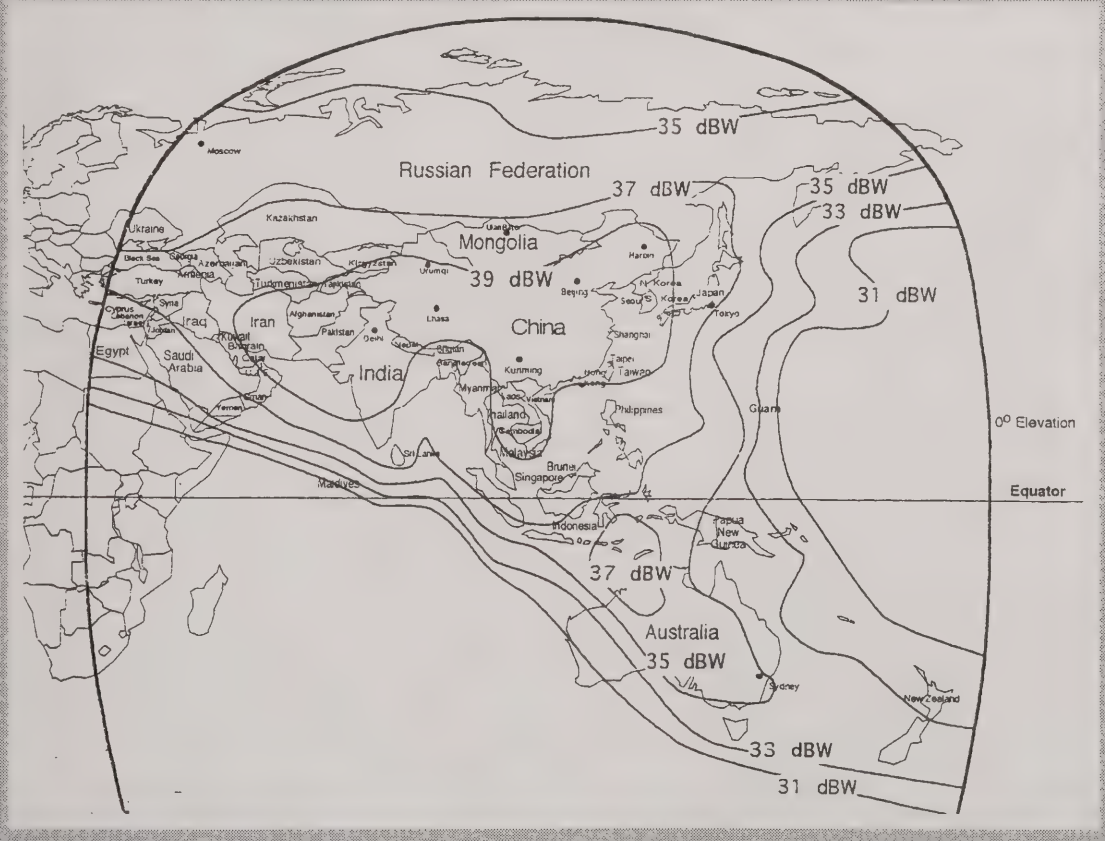
Origin Hong Kong
Type HS 601HP
Stabilisation 3 Axis
Norad # 25657

ASIASAT 3
Located at 105.5 degrees E

Asiasat 5 will be co-located with this satellite during 2004

TRANSPONDERS

C band	28 + 6
Power	55 Watts
Bandwidth	28 x 36MHz
Coverage	Asia / Australia India Middle East
Polarisation	Linear
Ku Band	16 + 4
Power	138 Watts
Bandwidth	16 x 54 MHz
Coverage	China / India
Polarisation	Linear



Footprint source: Asiasat

Satellite Data for Orbital Locations

Launch Date 28/11/95
Launch Vehicle LM2E #23
Mass In Orbit 1500 Kg
Design Lifetime 15 years

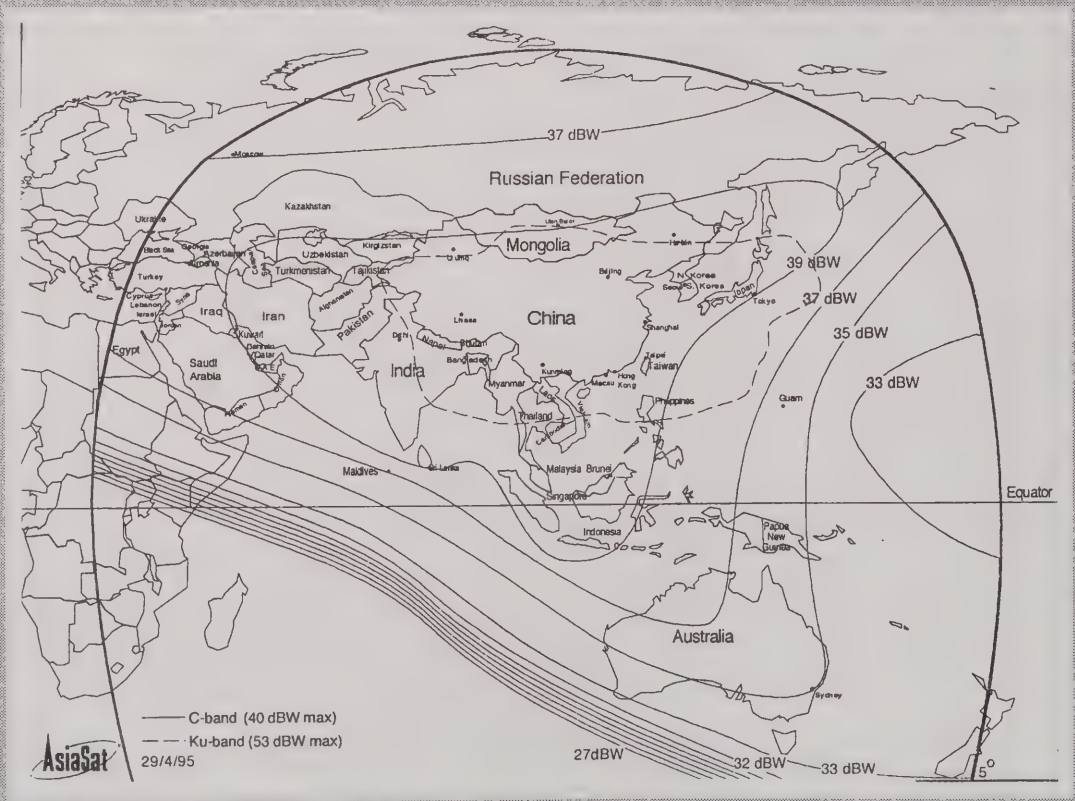
Origin Hong Kong
Type GE 7000
Stabilisation 3 Axis
Norad # 23723

ASIASAT 2
Located at 100.5 degrees E

Photo source: Av-Comm

TRANSPONDERS

C band	24 + 6
Power	55 Watts
Bandwidth	20 x 36MHz 4 x 72 MHz
Coverage	Asia/Australia
Polarisation	Linear
Ku Band	9
Power	115 watts
Bandwidth	9 x 54 MHz
Coverage	China
Polarisation	Linear



Footprint source: Asiasat

Satellite Data for Orbital Locations

Launch Date 28/10/1993
Launch Vehicle Proton #217
Launch Mass 2120 Kg
Design Lifetime 3 years

Origin CIS
Type NPO Gorizont
Stabilisation 3 Axis
Norad # 22880

GORIZONT 28 (#40)
Located at 96.5 degrees E

No North-South axis control.
Inclined orbit.
Will be replaced by Express AM11 before 2005

TRANSPONDERS

C band	6
Power	1 x 40 Watts
	5 x 15 Watts
Bandwidth	6 x 34 MHz
Coverage	Asia, CIS
Polarisation	LHCP
Ku Band	1
Power	1 x 20 Watts
Bandwidth	1 x 34 MHz
Coverage	CIS
Polarisation	LHCP

Satellite operated by the Russian Satellite Communications Company (Federal State Unitary Enterprise)

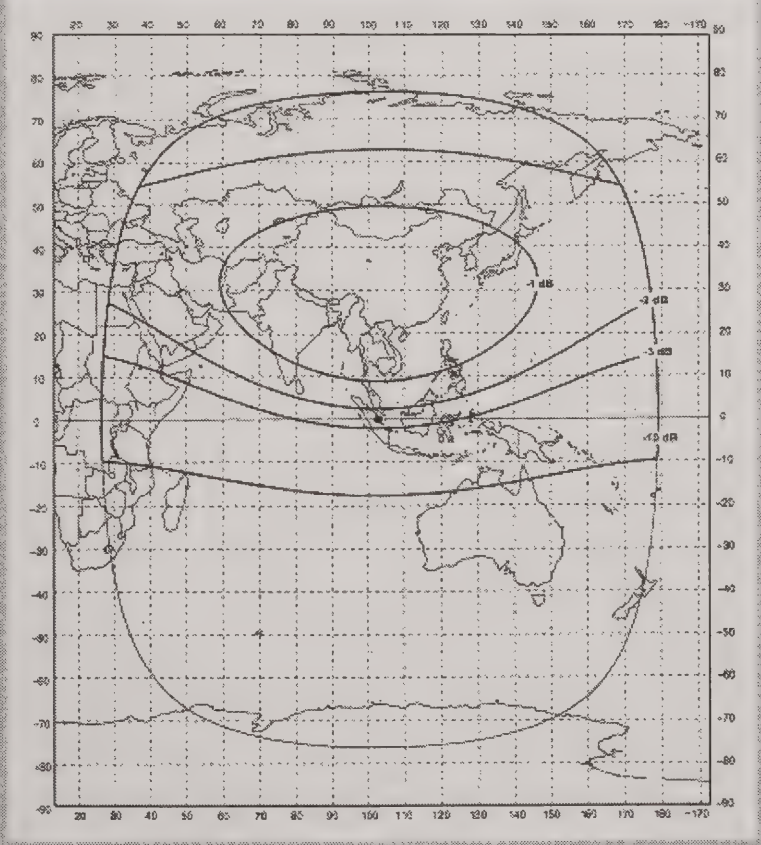
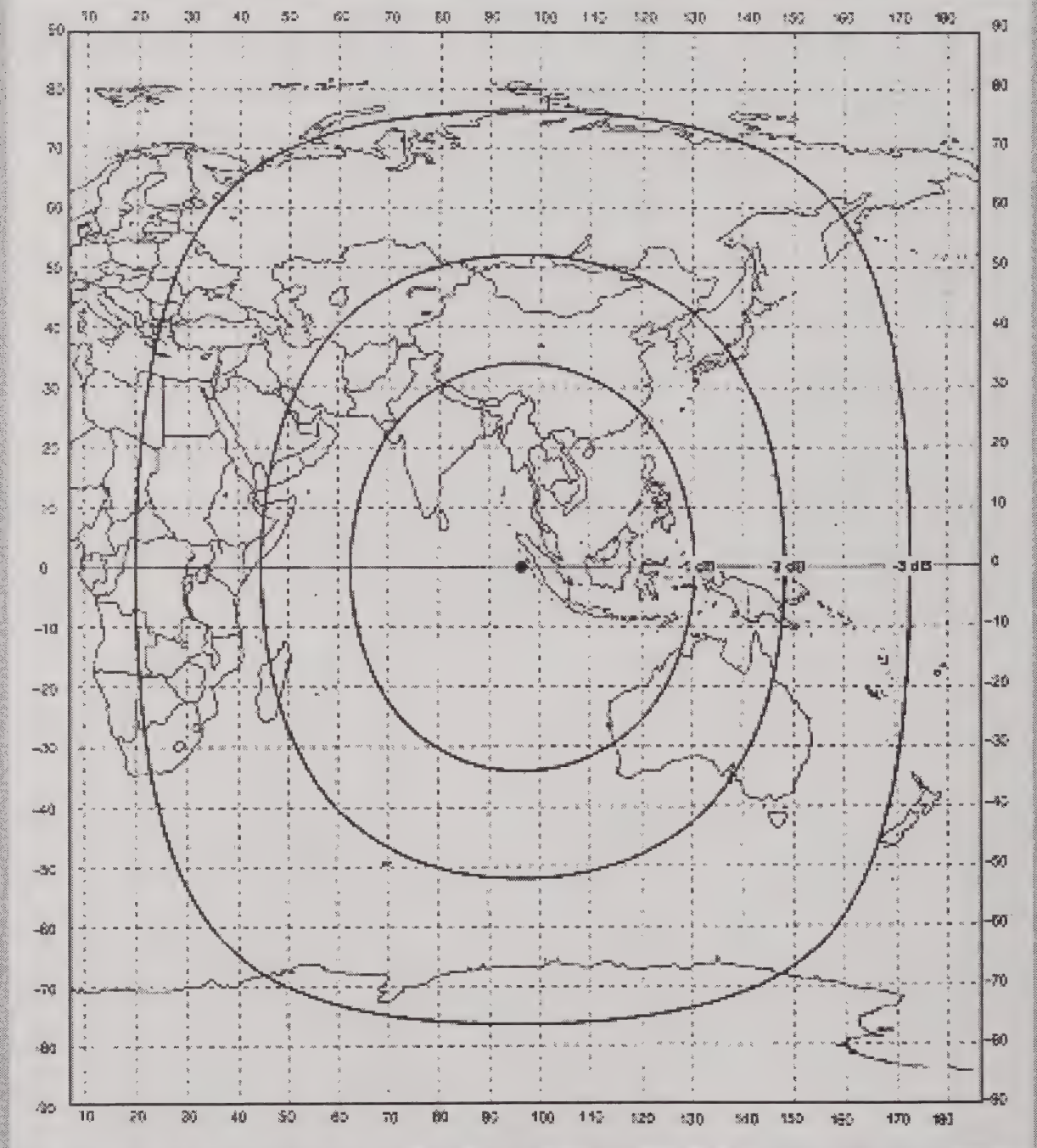


Photo source: Av-Comm

Footprint source: www.rscc.ru

Satellite Data for Orbital Locations



Footprint source: RSCC

Satellite Data for Orbital Locations

Launch Date 17/12/02
Launch Vehicle Ariane V156
Mass In Orbit 4750Kg
Design Lifetime 15 years

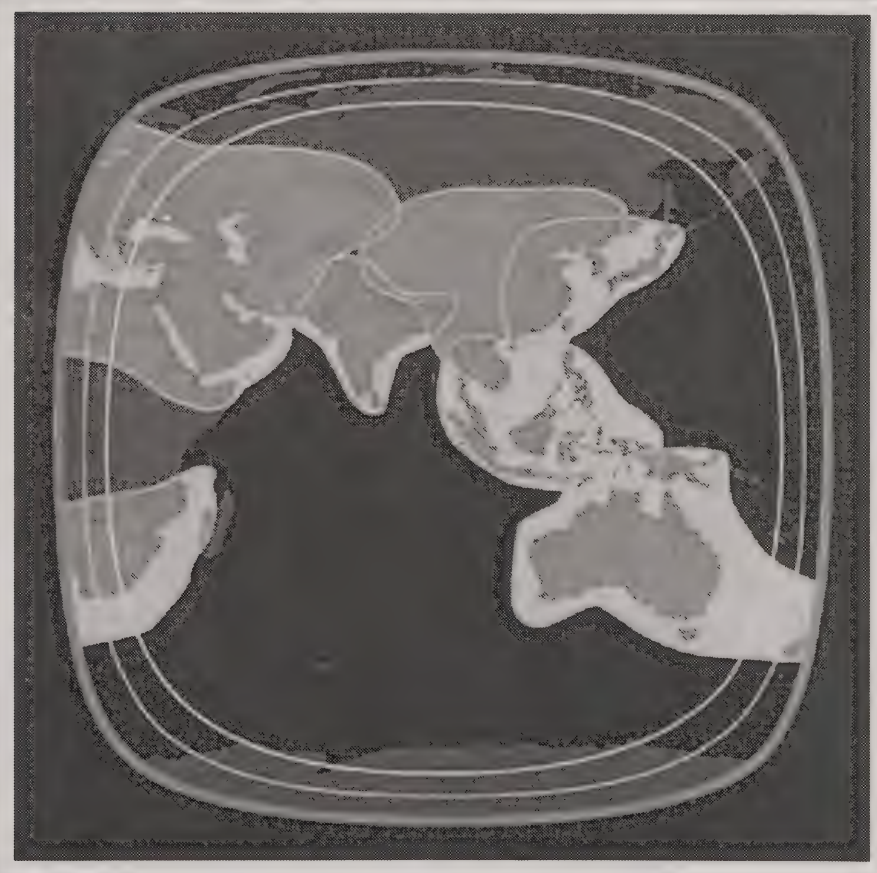
Origin International
Type LM A2100AX
Stabilisation 3 axis
Norad # 27603

NSS-6
Located at 95 degrees E

Located 27.5W 9/97 to 12/97
Located 21.5W 1/98 to 8/02
Located 19.8W 8/02 to 10/02
Located 183E 2003

TRANSPONDERS

K band	50
Power	50 x 100 Watts
Bandwidth	60 x 36MHz
Coverage	India, China, Australia Middle East, NE & SE Asia
Polarisation	Linear



Footprint source: New Skies

Satellite Data for Orbital Locations

Launch Date 09/4/2003
Launch Vehicle Ariane V160
Mass In Orbit 1348 Kg
Design Lifetime 12 years

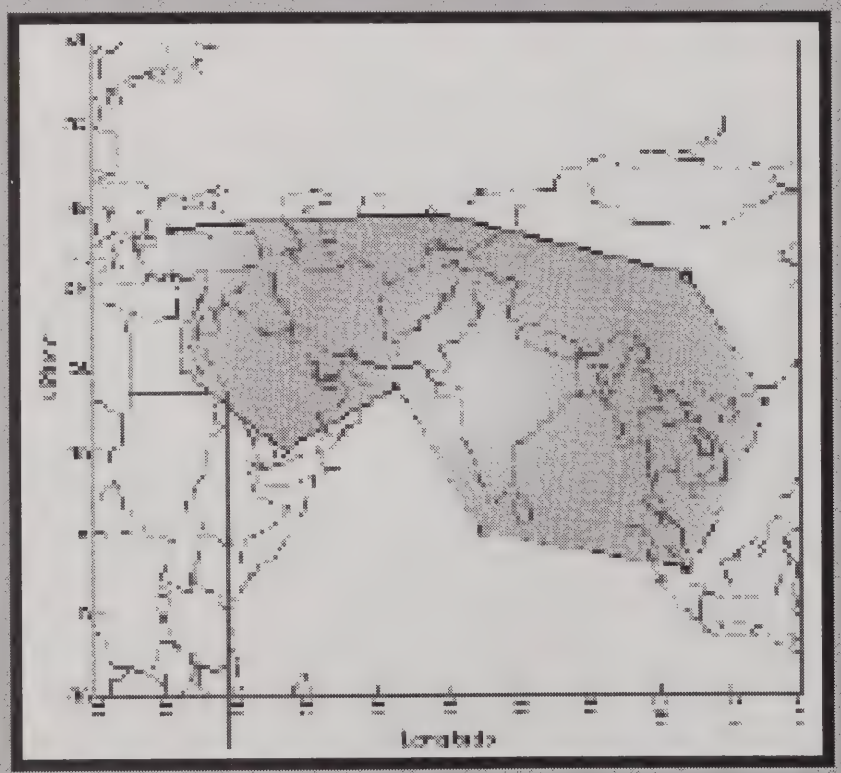
Origin India
Type Insat 3
Stabilisation 3 axis
Norad # 27714

Insat 3a
Located at 93.5 degrees E

TRANSPONDERS

C band	12
Power	10/16/20/30 W
Bandwidth	9 x 36 MHz
Coverage	India & Pacific
Polarisation	Linear

Although the official footprint is restricted to India and northern Asia, good signals have been observed along the east coast of Australia.



Footprint: www.isro.org

Satellite Data for Orbital Locations

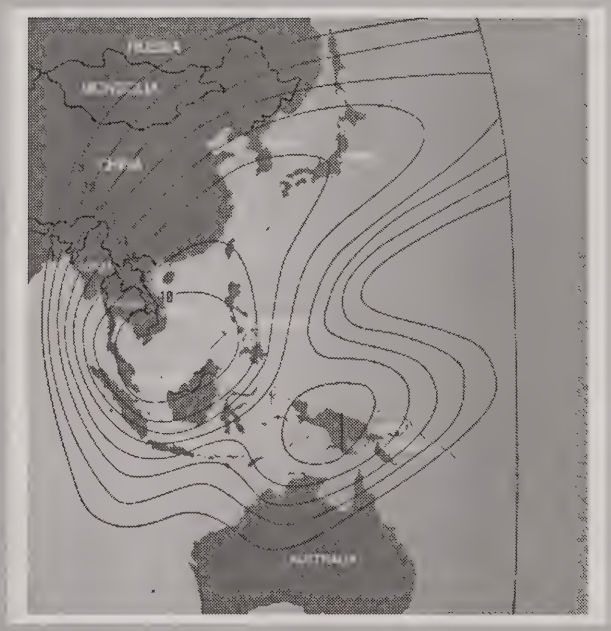
Launch Date 13/1/1996
Launch Vehicle Ariane V82
Mass In Orbit 1348 Kg
Design Lifetime 12.2 years

Origin Malaysia
Type HS 376
Stabilisation Spin
Norad # 23765

Measat 1
Located at 91.5 degrees E

TRANSPONDERS

C band	12
Power	112 Watts
Bandwidth	12 x 36MHz
Coverage	East Asia, Nth Australia, Guam
Polarisation	Linear
Ku Band	4
Power	112 Watts
Bandwidth	4 x 54MHz
Coverage	Malaysia Philippines India
Polarisation	Linear



Measat-3 will be co-located at 91.5E during 2005

Footprint source:www.measat.com

Satellite Data for Orbital Locations

Launch Date 2005
Launch Vehicle Proton Breeze
Mass In Orbit Classified
Design Lifetime 15 years

Origin Malaysia
Type Boeing 601HP
Stabilisation 3 axis
Norad # TBA

Measat 3
To be located 91.5 degrees E

TRANSPONDERS

C band	24
Power	112 Watts
Bandwidth	24 x 36MHz
Coverage	Australia Africa Middle East Asia
Polarisation	Linear
Ku Band	4
Power	112 watts
Bandwidth	4 x 54MHz
Coverage	Malaysia Indonesia India China
Polarisation	Linear

Footprint source:www.measat.com

Satellite Data for Orbital Locations

Launch Date 25/08/98	**Orgin** Sin/Taiwan
Launch Vehicle Ariane V107	**Type** Eurostar 2000+
Mass In Orbit 1750 Kg	**Stabilisation** 3 Axis
Design Lifetime 12 years	**Norad #** 25460

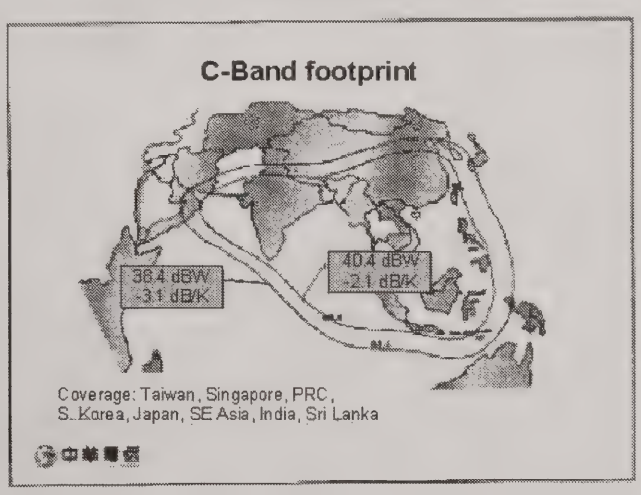
ST-1
Located at 88 degrees E

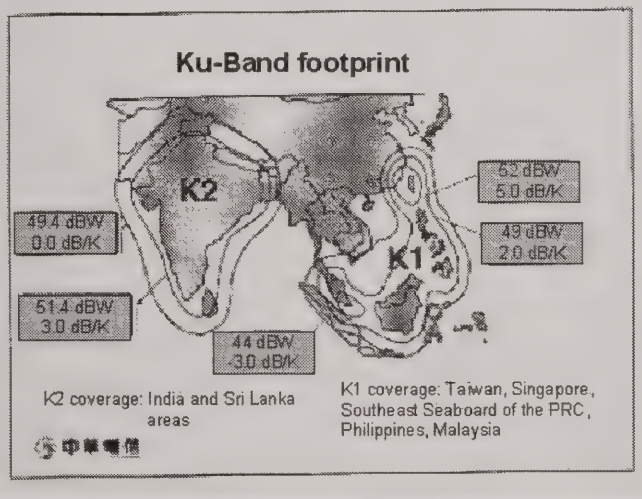
C band signals have been observed along the east coast of Australia, as far south as Sydney. Jointly owned by SingTel and Chunghwa Telecom Taiwan.

TRANSPONDERS

C band	14
Power	50 Watts
Bandwidth	14 x 36MHz
Coverage	Central & Eastern Asia
Polarisation	Linear
Ku Band	16
Power	100 watts
Bandwidth	40 x 36MHz
Coverage	Taiwan, Malaysia Singapore, Philippines India
Polarisation	Linear

Fig. 3: Footprints for ST-1





Footprint source: www.atip.or.jp

Satellite Data for Orbital Locations

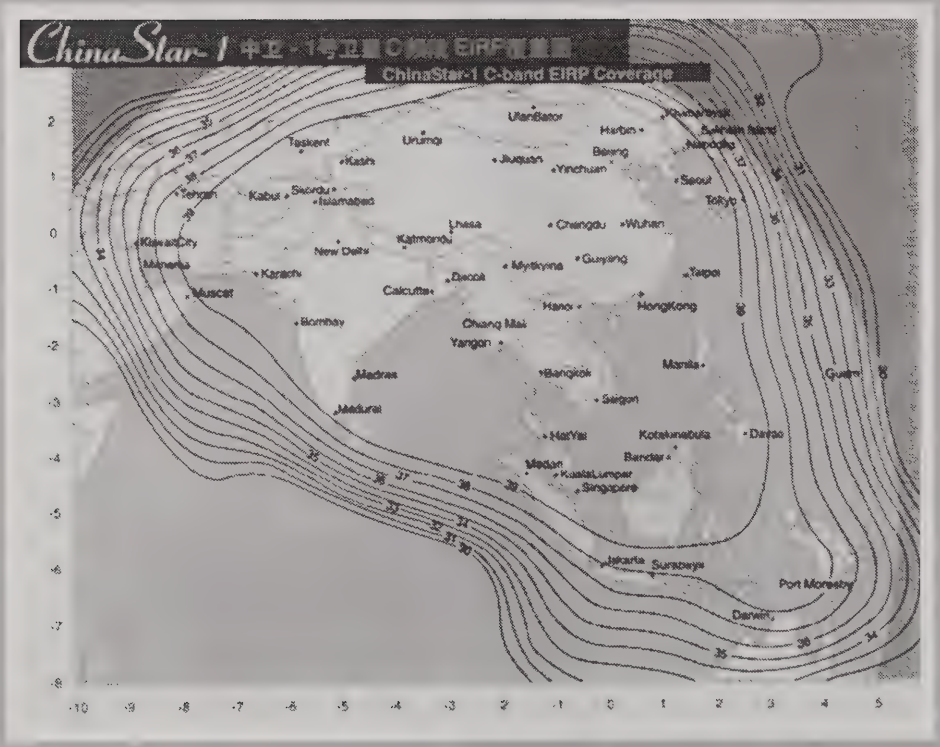
Launch Date 30/05/98	**Origin** China
Launch Vehicle LM3B #19	**Type** FS 1300
Mass In Orbit 1415 Kg	**Stabilisation** 3 Axis
Design Lifetime 15 years	**Norad #** 25354

CHINASTAR 1
Located at 87.5 degrees E

Also known as Zhongwei 1

TRANSPONDERS

C Band	18
Power	45 Watts
Bandwidth	12 x 36 MHz
	6 x 72 MHz
Coverage	Asia / Australia
	India
	Parts of Europe
Polarisation	Linear
K Band	20 + 10
Power	85 watts
Bandwidth	4 x 72 MHz
	16 x 36 MHz
Coverage	China
Polarisation	Linear



Footprint source: Chinastar

Satellite Data for Orbital Locations

Launch Date: 15/6/96
Launch Vehicle: Ariane V87
Mass In Orbit: 1800Kg
Design Lifetime: 10 years

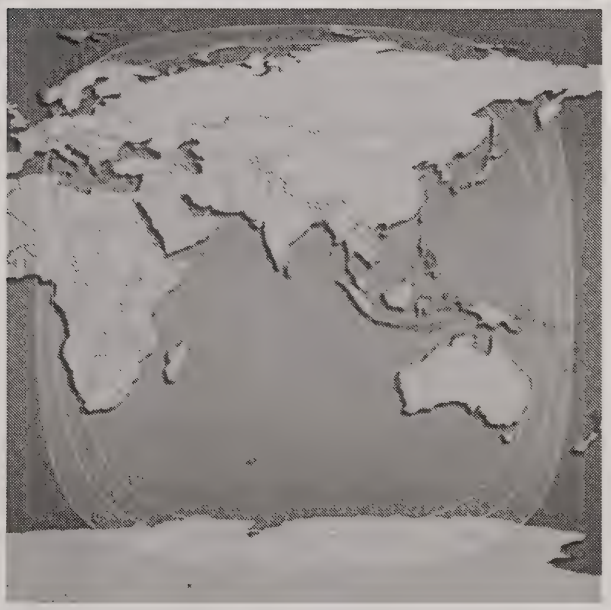
Origin: International
Type: FS1300
Stabilisation: 3 Axis
Norad #: 23915

Intelsat 709
To be located 85 degrees E

Located 50 degrees W after launch
Deployed at 55 degrees E during 2002-03
Will be replaced by Intelsat 706 in 2004
Intelsat 709 to be then deployed at 157E in 2004

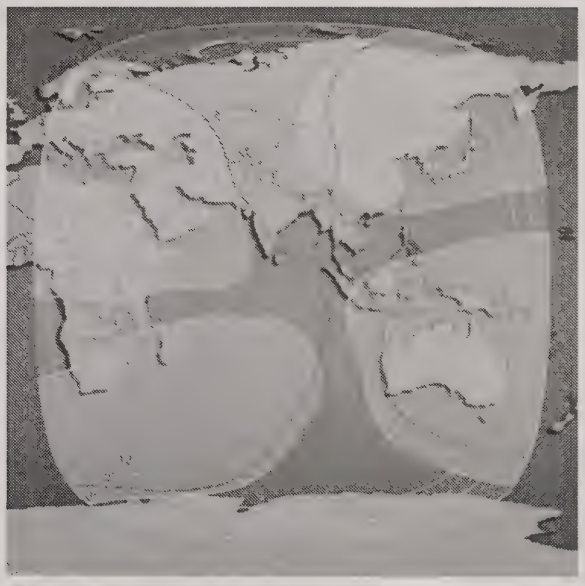
TRANSPONDERS

C Band	28
Power	10,16,28,30W
Bandwidth	10 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	A.P.R.
Polarisation	RHCP/LHCP
Ku Band	10
Power	5 x 35W
	5 x 50W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear



Intelsat 709 at 85 degrees east.

Footprint source: www.intelsat.int



Intelsat 706 at 85 degrees east

Satellite Data for Orbital Locations

Launch Date 2/04/2000
Launch Vehicle Ariane V117
Mass In Orbit 1526 Kg
Design Lifetime 12 years

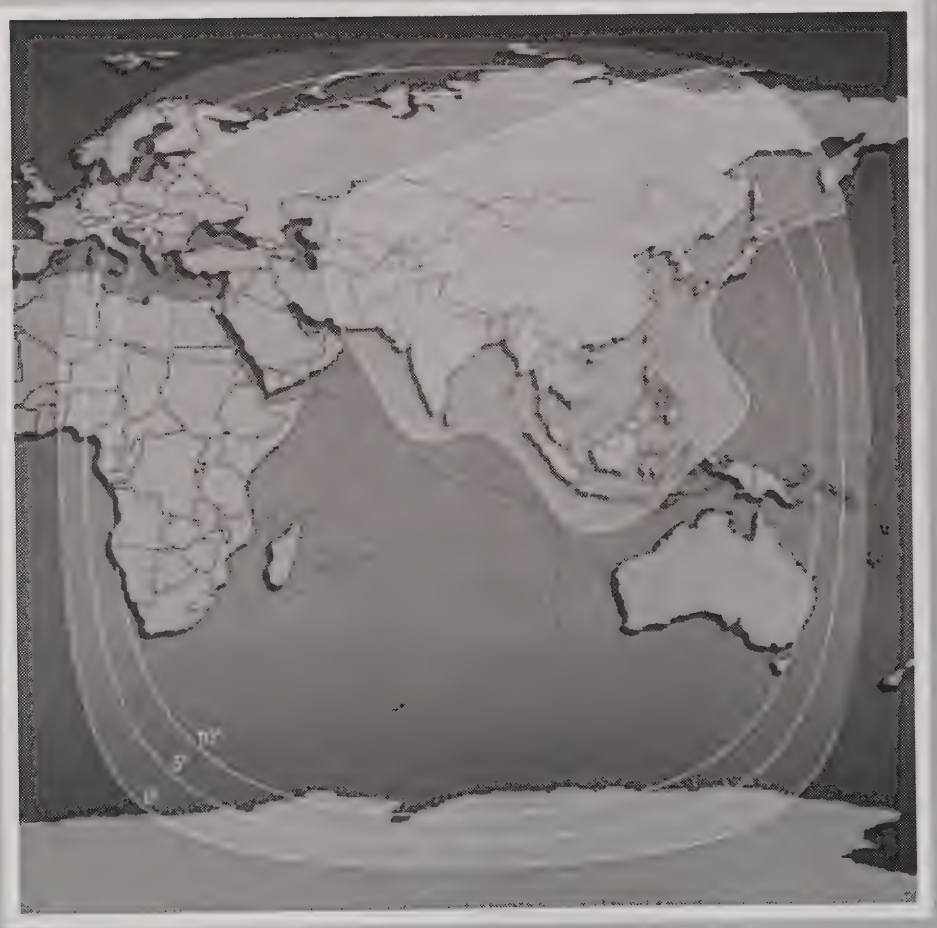
Origin India
Type Insat 2
Stabilisation 3 axis
Norad # 25666

INSAT 2E / APR-1
Located at 83 degrees E

Satellite also carries: Very High Resolution Radiometer with 2Km visible and 8 Km infra red resolution, and CCD camera with 1 Km resolution. Intelsat has a ten year lease on 11 transponders.

TRANSPONDERS

C Band	15 + 2
Power	32, 60 Watts
Bandwidth	15 x 36 MHz 2 x 72 MHz
Polarisation	Linear
Coverage	Malaysia, Aust N Vietnam Indonesia



Footprint source: www.intelsat.int

Satellite Data for Orbital Locations

Launch Date 16/04/97	**Origin** Thailand
Launch Vehicle Ariane V95	**Type** Spacebus 3000A
Mass In Orbit 1560 Kg	**Stabilisation** 3 Axis
Design Lifetime 14 years	**Norad #** 24768

THAICOM 3
Located at 78.5 degrees E

Co-located with Thaicom 2

TRANSPONDERS

C Band	7 + 18 + 2
Power	11 Watts
Bandwidth	25 x 36 MHz
Coverage	Asia / Australia Europe Africa / Thailand, China Indonesia
Polarisation	Linear
Ku Band	14
Power	115 Watts
Bandwidth	2 x 54 MHz 5 X 36 MHz
Coverage	Thailand
Polarisation	Linear

Footprint source: Shin Satellite

Satellite Data for Orbital Locations

Launch Date 16/10/97
Launch Vehicle LM3B #18
Mass In Orbit 1415 Kg
Design Lifetime 15 years

Origin China
Type FS 1300
Stabilisation 3 Axis
Norad # 25010

APSTAR 2R/ Telstar 10
Located at 76.5 degrees E

TRANSPONDERS

C Band	28
Power	60 Watts
Bandwidth	1 x 30 MHz 27 x 36 MHz
Coverage	Asia / Australia Parts of Europe
Polarisation	Linear
K Band	16
Power	110 watts
Bandwidth	15 x 54 MHz 1 X 36 MHz
Polarisation	Linear

Footprint source: APT Satellite Co Ltd

Satellite Data for Orbital Locations

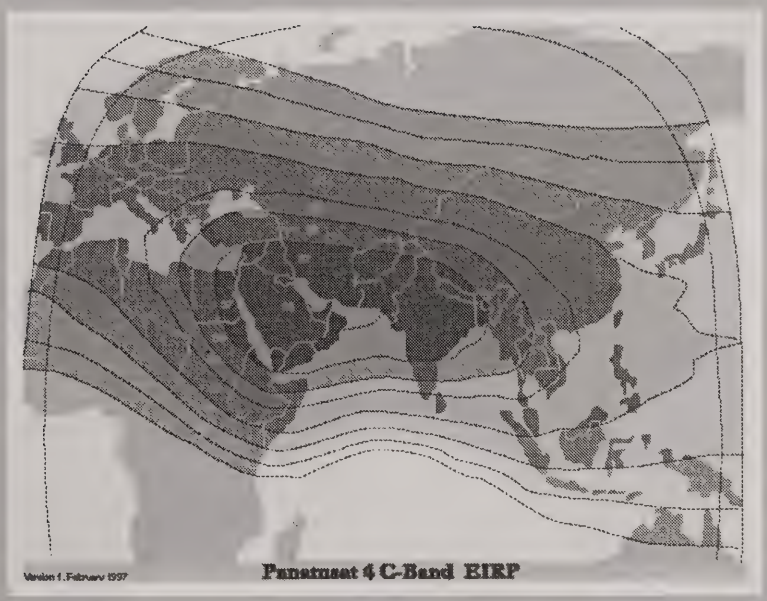
Launch Date 03/08/95
Launch Vehicle Ariane V76
Mass In Orbit 2920 Kg
Design Lifetime 15 years

Origin USA
Type HS-601
Stabilisation 3 Axis
Norad # 23636

PANAMSAT 4
Located at 72 degrees E

TRANSPONDERS

C band	16
Power	30 Watts
Bandwidth	12 x 54MHz 4 x 64 MHz
Coverage	Europe / Africa S.E. Asia Singapore W. Australia S China
Polarisation	Linear
Ku Band	24
Power	60 watts
Bandwidth	16 x 27 MHz 2 x 64 MHz
Coverage	Europe Middle East S. Africa Indonesia
Polarisation	Linear



Footprint source: www.geo-orbit.org

Satellite Data for Orbital Locations

Launch Date 016/09/98	**Origin** USA
Launch Vehicle Ariane V110	**Type** FS-1300
Mass In Orbit 2120 Kg	**Stabilisation** 3 Axis
Design Lifetime 15 years	**Norad #** 25473

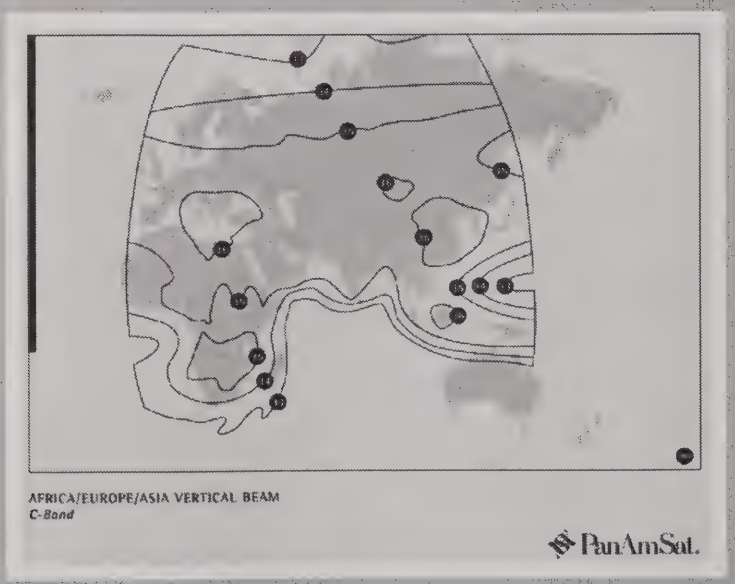
PANAMSAT 7
Located at 68.5 degrees E

Used to expand South African capacity.
Spacecraft rumoured to have suffered some malfunction Sept 2001 reducing power supply capacity by approximately 25%

TRANSPONDERS

C band	14 + 4
Power	50 Watts
Bandwidth	18 x 36MHz
Coverage	Europe / Africa Asia
Polarisation	Linear
Ku Band	30 + 10
Power	100 watts
Bandwidth	40 x 36MHz
Coverage	Europe Middle East South Africa India
Polarisation	Linear

Footprint source: www.panamsat.com



Satellite Data for Orbital Locations

Launch Date 14/05/2001
Launch Vehicle Proton # 287
Mass In Orbit 2920 Kg
Design Lifetime 15 years

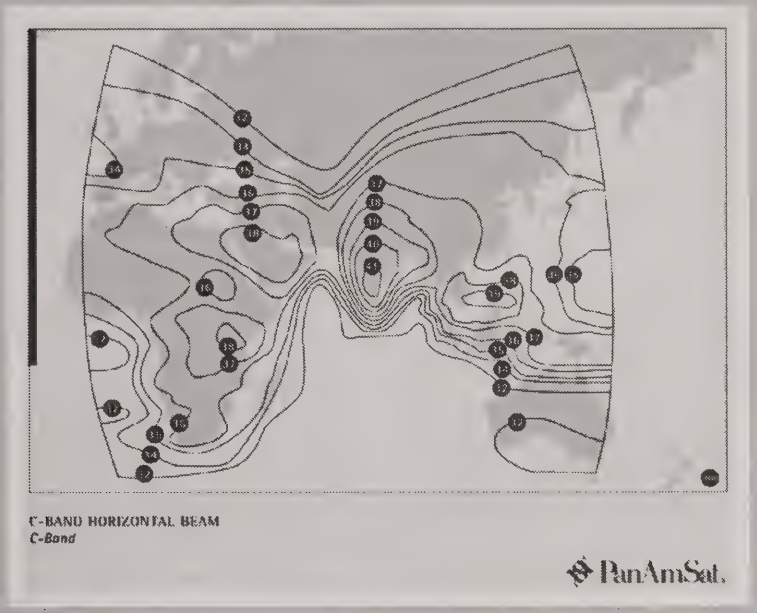
Origin USA
Type Boeing 601HP
Stabilisation 3 Axis
Norad # 26766

PANAMSAT 10
Co-located at 68.5 degrees E

Replaces Pas - 4 which is rumored to have lost one control processor due to a "Tin Whisker" problem.

TRANSPONDERS

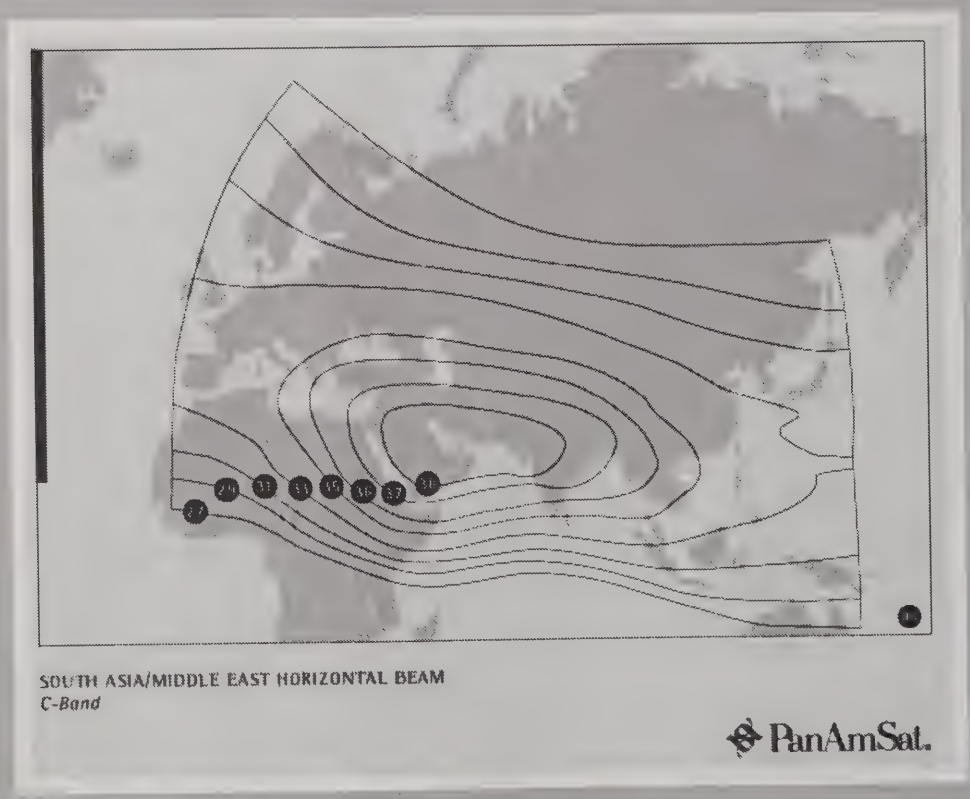
C band	24 + 8
Power	55 Watts
Bandwidth	8 x 54MHz 16 x 72 MHz
Coverage	Asia, Europe, Middle East, Africa
Polarisation	Linear
Ku Band	24 + 8
Power	98 watts
Bandwidth	24 x 36 MHz
Coverage	Europe Middle East Africa, Asia
Polarisation	Linear



Footprint source: www.panamsat.com

Satellite Data for Orbital Locations

Footprint source: www.panamsat.com



Launch Date 10/01/95	**Origin** International
Launch Vehicle Atlas Centaur #87	**Type** FS1300
Mass In Orbit 1800 Kg	**Stabilisation** 3 Axis
Design Lifetime 15 years	**Norad #** 23461

INTELSAT 704
Located at 66 degrees E

TRANSPONDERS

C band	28
Power	10/16/20/30 W
Bandwidth	10 x 36MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R
Polarisation	Circular
Ku Band	10
Power	5 x 35 watts
	5 x 55 Watts
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

Footprint:www.intelsat.int

Satellite Data for Orbital Locations

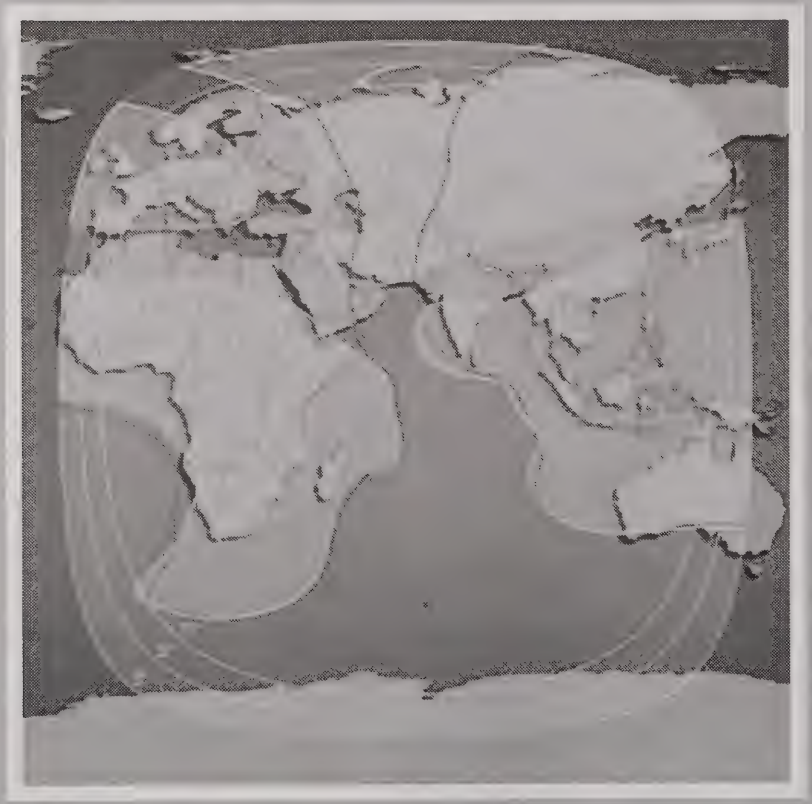
Launch Date 6/09/2002
Launch Vehicle Ariane V 142
Mass In Orbit 1970 Kg (est)
Design Lifetime 13 years

Origin International
Type FS1300HL
Stabilisation 3 Axis
Norad # 27513

INTELSAT 906
Located at 64.15 degrees E

TRANSPONDERS

C band	72
Power	Classified
Bandwidth	72 x 36 MHz
Coverage	Asia, Europe Parts of Africa Australia
Polarisation	Circular
Ku Band	22
Power	Classified
Bandwidth	22x 36 MHz
Coverage	Europe, India
Polarisation	Linear



Footprint:www.intelsat.int

Satellite Data for Orbital Locations

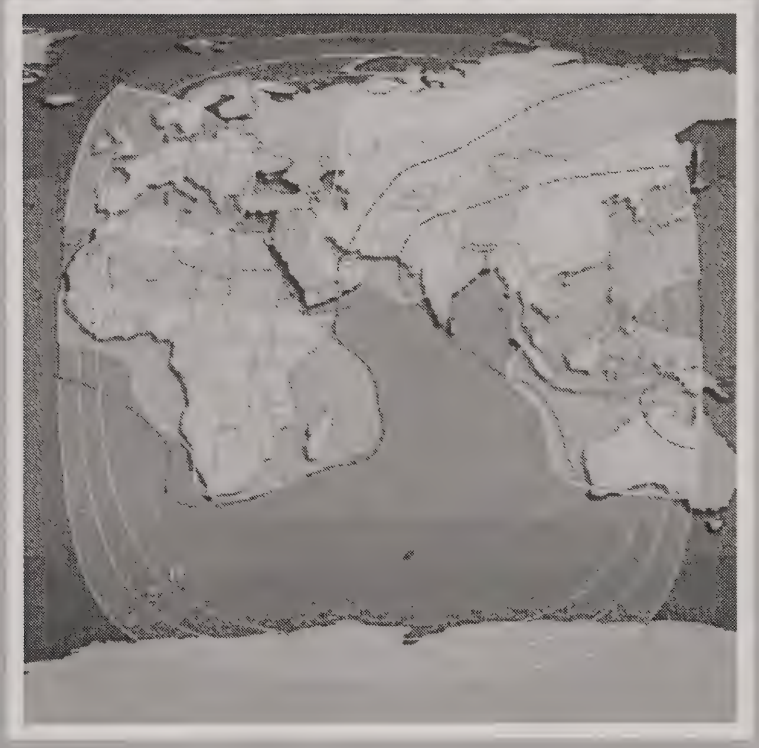
Launch Date 30/08/01
Launch Vehicle Ariane V143
Mass In Orbit 1980 Kg
Design Lifetime 15 years

Origin International
Type FS1300 HL
Stabilisation 3 Axis
Norad # 26900

INTELSAT 902
Located at 62 degrees E

TRANSPONDERS

C band	44
Power	Classified
Bandwidth	32 x 72 MHz 12 x 36 MHz
Coverage	I.O.R.
Polarisation	Circular
Ku Band	16
Power	5 x 35 watts 5 x 55 Watts
Bandwidth	8 x 72 MHz 8 x 36 MHz
Coverage	Europe, Middle East
Polarisation	Linear



Footprint: www.intelsat.int

Satellite Data for Orbital Locations

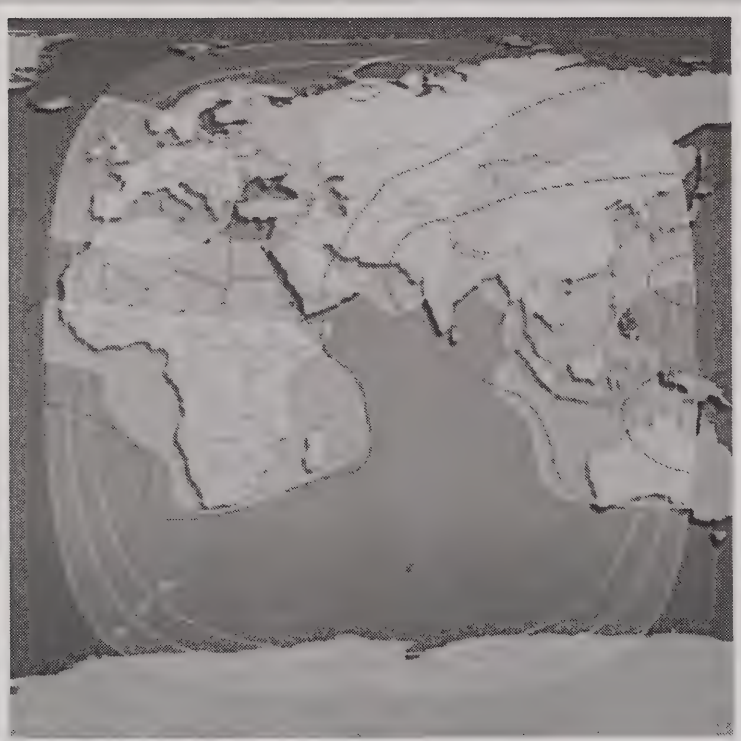
Launch Date 23/02/2002
Launch Vehicle Ariane V148
Mass In Orbit 1970 Kg
Design Lifetime 15 years

Origin International
Type FS1300HL
Stabilisation 3 Axis
Norad # 27380

INTELSAT 904
Located at 60 degrees E

TRANSPONDERS

C band	44
Power	Classified
Bandwidth	32 x 72 MHz 12 x 36 MHz
Coverage	I.O.R.
Polarisation	Circular
Ku Band	16
Power	Classified
Bandwidth	8 x 72 MHz 8 x 36 MHz
Coverage	Europe, N Asia Africa, Russia
Polarisation	Linear

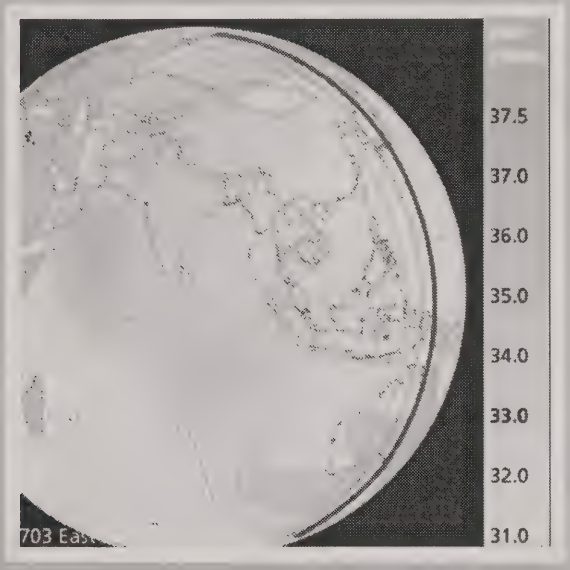


Footprint: www.intelsat.int

Satellite Data for Orbital Locations

Launch Date 06/10/94 **Origin** International
Launch Vehicle Atlas Centaur #85 **Type** FS 1300
Mass In Orbit 1800 Kg **Stabilisation** 3 axis
Design Lifetime 15 years **Norad #** 23305

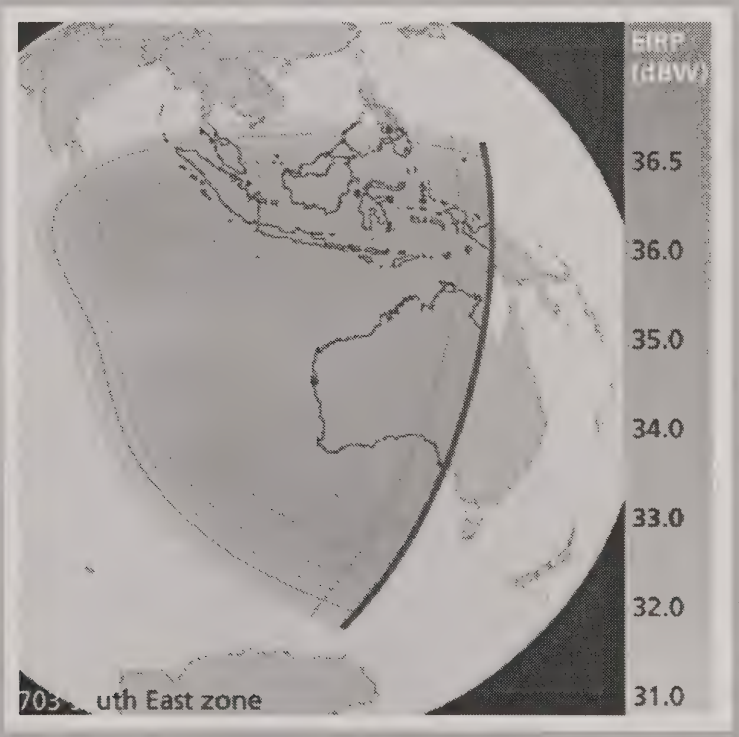
NSS-703
Located at 57 degrees E



TRANSPONDERS

C band	24
Power	10/16/20/30 W
Bandwidth	8 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R.
Polarisation	Circular
K band	10
Power	35 and 50 W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

Located 27.5W 9/97 to 12/97
Located 21.5W 1/98 to 8/02
Located 19.8W 8/02 to 10/02
Located 183E 2003



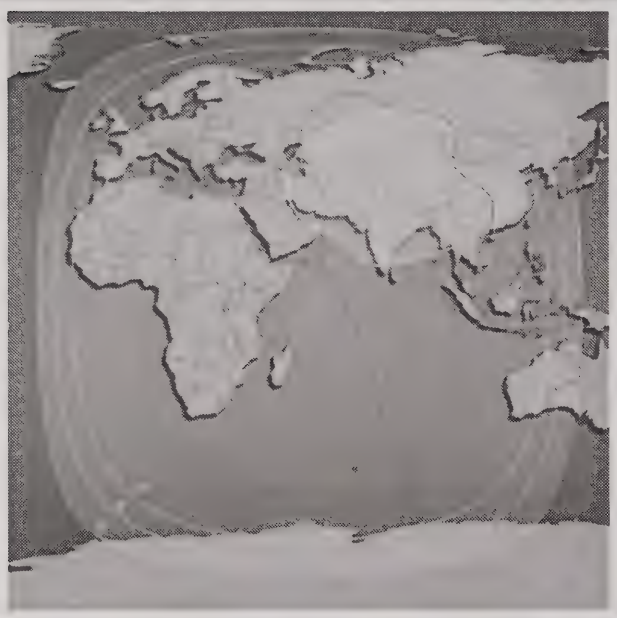
Footprint source: New Skies

Satellite Data for Orbital Locations

Launch Date 17/6/94
Launch Vehicle Ariane V64
Mass In Orbit 1800 Kg
Design Lifetime 15 years

Origin International
Type FS 1300
Stabilisation 3 axis
Norad # 23124

Intelsat 702
Located at 55 degrees E



TRANSPONDERS

C band	24
Power	10/16/20/30 W
Bandwidth	8 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R.
Polarisation	Circular
K band	10
Power	35 and 50 W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

Footprint:www.intelsat.com

Satellite Data for Orbital Locations

Launch Date 29/12/2003
Launch Vehicle Proton K #303
Mass In Orbit 590 Kg
Design Lifetime 12 years

Origin CIS
Type NPO Express
Stabilisation 3 axis
Norad # 28134

Express AM22
Located at 53 degrees E

TRANSPONDERS

K band	24
Power	103.5 W
Bandwidth	6 x 72 MHz 4 x 112 MHz
Coverage	I.O.R.

Footprint: www.rscc.ru

Satellite Data for Orbital Locations

Launch Date 27/10/89
Launch Vehicle Ariane V34
Mass In Orbit 2560 Kg
Design Lifetime 10 years

Origin International
Type HS 389
Stabilisation Spin
Norad # 20315

Intelsat 602
Located at 50.5 degrees E

TRANSPONDERS

C band	64
Power	10/16/20/30W
Bandwidth	8 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R.
Polarisation	Circular
K band	24
Power	35 and 50 W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

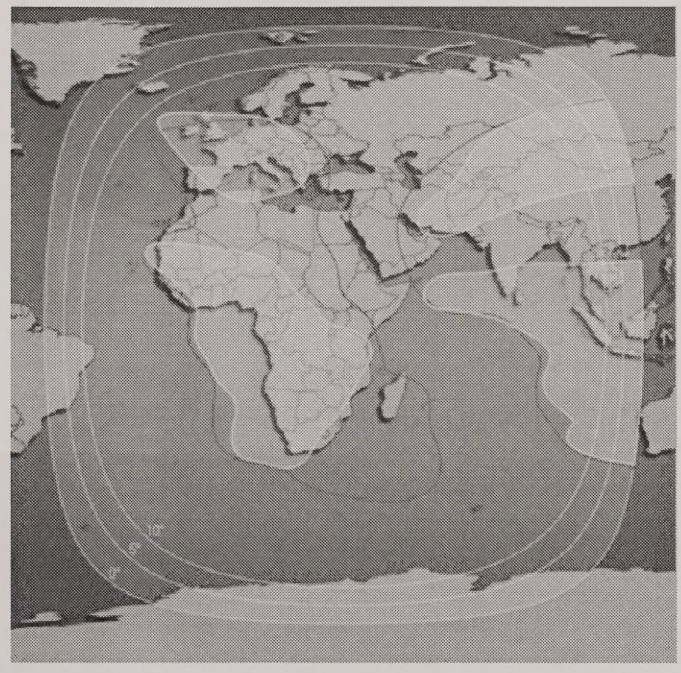
Footprint:www.intelsat.com

Satellite Data for Orbital Locations

Launch Date 14/08/91
Launch Vehicle Ariane V45
Mass In Orbit 2560 Kg
Design Lifetime 10 years

Origin International
Type HS 389
Stabilisation Spin
Norad # 21653

Intelsat 605
Located at 33 degrees E



TRANSPONDERS

C band	64
Power	10/16/20/30 W
Bandwidth	8 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R.
Polarisation	Circular
K band	10
Power	35 and 50 W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

Will be replaced by Intelsat 702 during 2004.

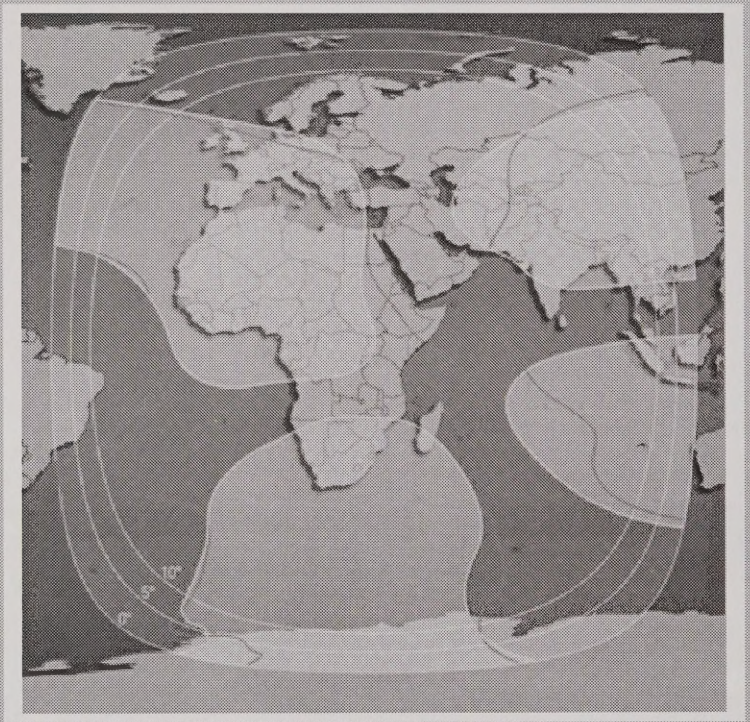
Footprint: www.intelsat.com

Satellite Data for Orbital Locations

Launch Date 17/6/94
Launch Vehicle Ariane V64
Mass In Orbit 1800 Kg
Design Lifetime 15 years

Origin International
Type FS 1300
Stabilisation 3 axis
Norad # 23124

Intelsat 702
To be located at 33 degrees E



TRANSPONDERS

C band	24
Power	10/16/20/30 W
Bandwidth	8 x 36 MHz
	2 x 41 MHz
	16 x 72 MHz
Coverage	I.O.R.
Polarisation	Circular
K band	10
Power	35 and 50 W
Bandwidth	6 x 72 MHz
	4 x 112 MHz
Coverage	I.O.R.
Polarisation	Linear

Will be moved to this location during 2004

Footprint: www.intelsat.com

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